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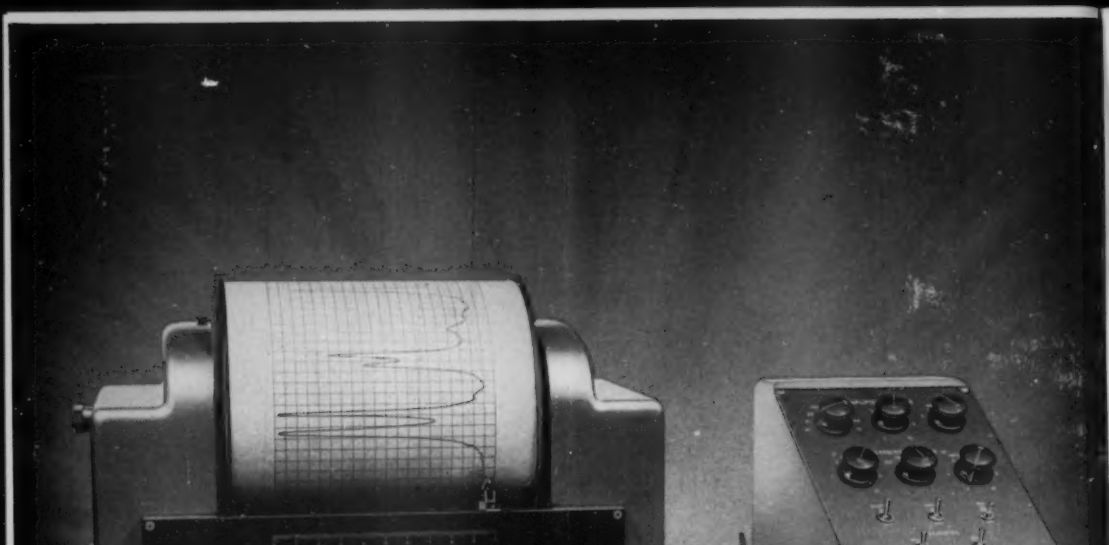

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Determination of Isotopic Masses and Abundances by Mass Spectrometry

Alfred O. Nier

Department of Physics, University of Minnesota, Minneapolis

MASS spectroscopy has developed in two principal directions (*1*). On one hand, research has progressed along the lines started by Aston, who, in 1919, completed the first mass spectrograph. Positive ions originating in a high-voltage glow discharge tube are sent through a combination of electric and magnetic fields in such a way they are sorted according to their masses. The separated beams of ions are allowed to impinge upon a photographic plate. From measurements of the positions and intensities of the lines found on the plate after development, one can determine both the masses of the ions and the relative abundances.

In recent years, most mass spectrographic work has been done with three basic types of instruments that were developed, respectively, by Mattauch (*2*), Bainbridge and Jordan (*3*), and Dempster (*4*). All have certain features in common. The unresolved ion beam leaving the ion source is sent through a portion of a cylindrical electrostatic condenser followed by a region in which there exists a magnetic field. With the proper arrangement of this geometry, these instruments can be given the property of focusing to a common point all ions that deviate slightly in energy and diverge slightly in direction. Such an instrument is said to be double focusing. Mass spectrographs have had their greatest usefulness in the field of determination of precise atomic masses.

The mass spectrometer. The other general approach in mass spectroscopy has been that which was originated by Dempster (*5*), who constructed the first mass spectrometer. Mass spectrometers have been simpler in design than mass spectrographs. Figure 1 is a schematic diagram of some essential parts of the type of mass spectrometer (*6*) that has been used extensively in recent years for the measurement of the relative abundances of isotopes or for making gas analyses. A heated tungsten filament F emits electrons that are collimated into a fine beam. The ions produced in the electron beam by collisions with gas or vapor molecules are accelerated by falling through the difference in potential between plates B and C. Because the ions are produced in a region of practically constant potential, all those that leave the ion source have very nearly the same energy. As they pass between the trapezoidal-shaped poles of a magnet, they are bent in circular paths, the radius of curvature depending upon the mass, the strength of the magnetic field, and the energy that the ions acquired in the ion source.

As is shown in Fig. 1, if the ion-source defining slit, the collector slit, and the apex of the effective magnetic field all lie on a straight line, direction focusing is produced. Ions that deviate slightly in direction as they leave the ion source are all focused on the collector slit. Instruments with various geometry have been employed. Dempster's original instrument was of the 180° type; that is, β was 180°, whereas α and γ were each 0°. In the interest of economy of construction, most modern instruments use a smaller angle β. An instrument in common use has α, β, and γ, each equal to 60°. Another instrument employed to some extent uses $\beta = 90°$, with α nd γ each equal to 45°.

The collector current due to the ion beam for a given isotope is relatively steady. Thus, it is convenient to use an electric measuring instrument, such as an electrometer tube amplifier, for measuring ion currents. A mass spectrum may be swept by changing either the accelerating voltage applied to the ions or the magnetic field. For detecting extremely small ion currents, electron multipliers followed by electrometer tube amplifiers are being used. It is common practice to connect the output of the measuring instrument to a strip-chart recorder and record the ion currents automatically as the mass spectrum is swept.

Relative abundance measurements. It is apparent, therefore, that such an instrument lends itself readily to abundance measurements, since it requires simply a measurement of electric current. In contrast, the use of a mass spectrograph for this purpose involves the more serious problem of converting the blackening of a photographic plate into a measure of beam intensity.

For precise measurement of relative abundances, two ion collectors may be employed along with two separate amplifiers. With a suitable electric measuring circuit one may then measure the ratio of the two ion currents. In this manner higher precision can be obtained with the same expenditure of effort that is required when a single collector is employed.

In 1933 almost all known isotope abundances had been measured with mass spectrographs; by 1942, 48 of the 83 naturally occurring elements had been measured by electric means. At the present time, 79 have been so determined.

Most isotope-abundance ratios are known to 1 percent or better, and the regions in the neighborhood of the known isotopes have been carefully explored for possible rare isotopes. It is unlikely that more than a few naturally occurring isotopes remain undiscovered.

The absolute values for most isotope-abundance ratios are known with sufficient accuracy for most practical purposes. Thus, the principal interest in further work lies in the applications of isotope-abundance measurements to other fields. For example, one of the extremely interesting fields today is the study of differences in isotope-abundance ratios resulting from chemical or nuclear effects that take place in nature. There is, of course, the important use of the mass spectrometer as a detecting device when stable isotopes are used as tracers in research in various chemical and biochemical fields.

Figure 2 is a mass spectrum determined with a 180° apparatus for the element mercury. We see here the seven isotopes of mercury, including the very rare one at mass 196. The sensitivity of measurements with an instrument of this kind is such that one can measure the relative abundance of this rare isotope to about the same precision as that of the other isotopes. If an electron multiplier is used as a detector, isotopes whose abundances are as low as 1 part in 1 million can be measured quite readily.

The double-focusing mass spectrometer. Several years ago we became interested in the possibility of using a double-focusing high-resolution mass spectrometer for the precision determination of atomic masses. A properly designed instrument would have certain advantages over conventional mass spectrographs: (i) Inasmuch as the ion currents are detected electrically, data may be taken continuously during the time the apparatus is undergoing adjustment in preparation for taking final measurements. (ii) Because of the high sensitivity it is possible to measure extremely rare isotopes. Consequently it should be possible to make systematic studies and measure isotopic masses for all the isotopes of a given element. (iii) The design and operation of the instrument would in general be sufficiently different from the mass spectrographs already in use, so that systematic errors, if they exist, should be different from those found in other instruments.

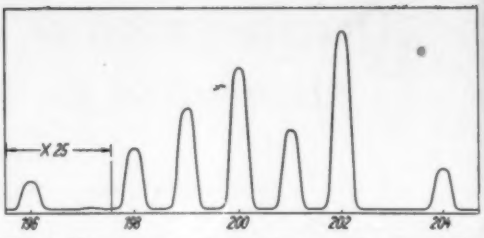

Fig. 2. Mass spectrum showing isotopes of mercury. The sensitivity in the region of Hg^{196} has been increased by a factor of 25 times in order to show the relatively rare isotope. The barely perceptible peak occurring between 196 and 198 is due to a hydrocarbon impurity present during the time this particular spectrum was taken. It is interesting to note that the small peak is slightly closer to the 198 than to the 196 peak. In high-resolution instruments, even those not intended primarily for precision determination of atomic masses, the spectra obtained often show displacements caused by differences in the deviation of masses from whole numbers.

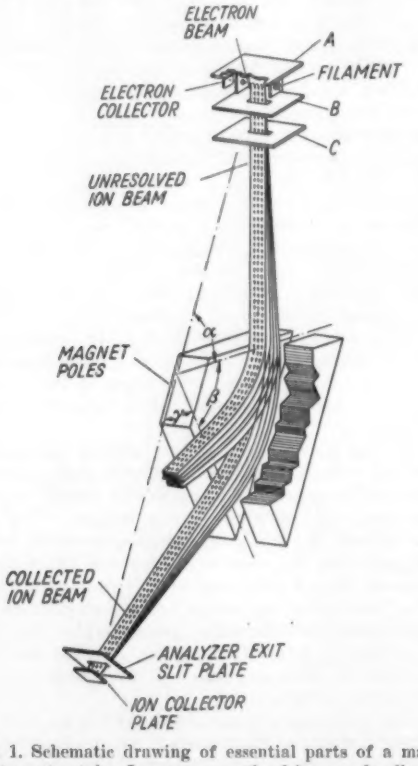

Fig. 1. Schematic drawing of essential parts of a mass-spectrometer tube. Ion source, path of ions, and collector arrangement are enclosed in a suitable envelope that is pumped continuously with a mercury or oil diffusion pump.

Figure 3 is a schematic view of the instrument that we designed. The ion source is similar to that employed in the conventional mass spectrometer. The ion beam is collimated by slits S_1 and S_2 and passes between the plates of a 90° segment of a cylindrical condenser. An energy spectrum is obtained in the plane of slit S_3. For illustrative purposes, ions having two different energies are shown in Fig. 3. The ions continue until they enter the gap between the trapezoidal-shaped poles of the magnetic field, where they are deflected, as in a mass spectrometer. A focus occurs finally at position S_4. When the beam trajectory and the geometric arrangement of both fields are properly (7) chosen, double focusing is produced in the same sense as in the mass spectrographs discussed earlier; that is, ions of slightly different energy and diverging slightly in angle as they leave slits S_1 and S_2 will focus at the same point, S_4.

The particular instrument that we have developed has a higher order of angle focusing (8) than more conventional instruments, with the result that slit S_3 in the ion source can be considerably wider than S_1

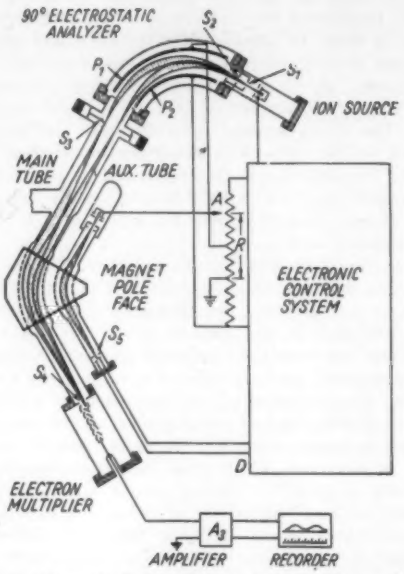

Fig. 3. Schematic drawing of double-focusing mass-spectrometer tube and associated control and measuring circuits.

without a sacrifice of resolution. The use of a larger exit angle at the ion source results, of course, in larger ion currents and consequently higher sensitivity than would be possible otherwise.

A small single-focusing mass spectrometer tube mounted in the same magnetic field is used to compensate for variations in the magnetic field or in the electric field appearing between plates P_1 and P_2 in the electrostatic analyzer. In the interest of simplicity, details of the circuit arrangement are not shown in Fig. 3 and may be found elsewhere (*9*). Suffice to say that a mass spectrum may be swept by changing the position of tap A on the resistor shown —that is, by changing the resistance R between point A and ground. A detailed analysis of this circuit indicates that the mass collected at slit S_4 is exactly proportional to the value of R.

The ion current is measured by means of an electron multiplier and amplifier, and the results are recorded on a standard strip-chart recorder.

Atomic mass determinations. Figure 4 shows the mass spectrum in the mass-28 region when a mixture of N_2 and CO are present. Although these two molecules differ in mass by only 1 part in 2500 the ion peaks are clearly resolved. The mass spectrum is swept by a motor that moves the point A (Fig. 3) and changes the resistance R at a uniform rate.

Actually all atomic masses are measured today by the "doublet" method. That is, one measures the mass difference between two molecules having approximately the same mass. If the mass of one component of the doublet is known, the mass of the other component may then be calculated from a knowledge of the mass difference. In practice, hydrocarbon fragments are generally used as the "known" masses. Because of the many possible combinations of hydrogen, carbon, and oxygen, one can choose a "known" standard for practically every mass-number position.

Physicists have not been able to agree upon the best values for the masses of carbon and hydrogen. Thus, the use of these as standards in computing other masses is unfortunate, although the range of uncertainty is small. Table 1 lists the most recent values for the masses of H^1 and C^{12}.

Figure 5 summarizes our knowledge of the atomic masses of atoms in the range from mass 10 to 210. The packing fraction is defined as $(M - A)/A$, where M is the measured mass and A is the nearest mass number. Plotted values below mass 32 are obtained from nuclear reactions given by Li (*10*). Those from mass 32 to 136 are based on our own measurements, whereas the heavier masses were obtained by Henry E. Duckworth of McMaster University, Canada, using a Dempster-type spectrograph.

All but a few of the known stable isotopes from mass 32 to 136 have been measured by the Minnesota group, so that it is possible to draw an essentially complete packing-fraction curve to a high order of accuracy in this region. It is seen that all atoms of odd mass number (indicated by X) lie on a relatively smooth curve, as is shown by the broken line. On the other hand, even mass isotopes for a given element (indicated by •) fall on a parabola, at least within

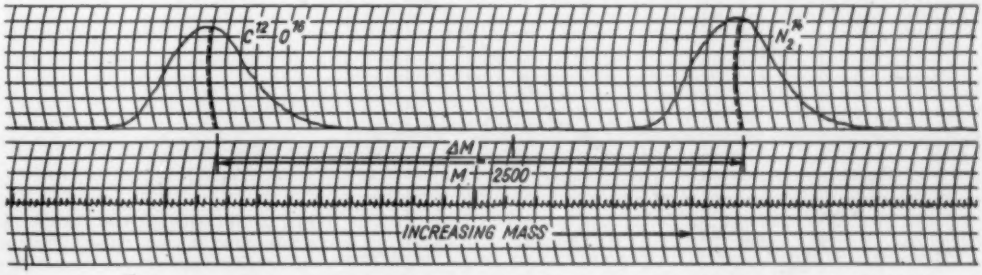

Fig. 4. Mass spectrum in region of mass 28 for a mixture of N_2 and CO. For this spectrum $S_1 = S_4 = 0.0125$ mm, $S_2 = 0.5$ mm, and $S_3 = 3$ mm. For other dimensions in apparatus, see reference 7.

Table 1. Recent values proposed for masses of H^1 and C^{12} (relative to $O^{16} = 16.0000$).

H^1	C^{12}	Method
1.008146 ± 3	12.003842 ± 4	Mass spectrometry*
1.008141 ± 2	12.003807 ± 11	Mass spectrometry†
1.008145 ± 2	12.003844 ± 6	Mass spectrometry‡
1.008142 ± 3	12.003804 ± 17	Nuclear reactions§
1.0081459 ± 5	12.0038231 ± 33	Mass spectrometry‖

* T. L. Collins, A. O. Nier, W. H. Johnson, Jr., *Phys. Rev.* **84**, 717 (1951).
† H. Ewald, *Z. Naturforsch*, pt. 6a, **293** (1951).
‡ K. Ogata and H. Matsuda, *Phys. Rev.* **89**, 27 (1953).
§ C. W. Li *et al.*, *ibid.* **33**, 512 (1951).
‖ J. Mattauch and R. Bieri, *Z. Naturforsch.* **9a**, 303 (1954).

experimental accuracy. An example of such a parabola is shown for the element xenon (Fig. 6), which has seven even mass isotopes. The curve was determined by a least squares fit, and it displays clearly the remarkable parabolic form. Further theoretical work is needed to explain this and other experimentally observed features of the entire packing-fraction curve.

Nevertheless, it is already possible, on the basis of these more accurate measurements, to verify certain theoretical aspects, notably of the "nuclear shell" theory. This theory predicts that the packing-fraction curve should show discontinuities in slope due to sudden changes in binding energy when the number of nuclear particles is one of the so-called "magic numbers"—14, 20, 28, 50, 82, and 126. Examples of such discontinuities are clearly seen at mass 28 (owing to the presence of 14 protons and 14 neutrons, both magic numbers), mass 40 (20 protons and 20 neutrons, also doubly magic), the region of mass 60 (28 protons), and the region below mass 90 (50 neutrons). Other less obvious cases can be seen on closer examination.

Isotope and gas analyses. We have recently become interested in the possibility of employing a double-focusing mass spectrometer for making isotope-abundance measurements as well as gas analyses. Accordingly, the slits in the instrument were widened somewhat in order to obtain better intensity and also to produce flat-topped peaks in the mass spectrum.

Figure 7 shows the mass spectrum over the region of CO_2 when a mixture of CO_2 and C_3H_8 were present. The large amount of C_3H_3 was deliberately chosen so that the peak in the 45-position corresponding to the molecules $C_2{}^{12}C^{13}H_8$ would be larger than the peak $C^{13}O_2{}^{16} + C^{12}O^{16}O^{17}$ that is usually found in CO_2 at mass 45 and is used for determining C^{13}/C^{12} abundance ratios.

It is clear from Fig. 7 that one can readily measure the mass 45/44 abundance ratio in CO_2 in spite of the fact that a very large "impurity" is present. As a matter of fact, the detailed analysis of the mass spectrum indicates that, although the two fragments in the mass-45 position differ in mass by only 1 part in 600, the resolution of the instrument is sufficient that the background of one fragment contributes only 1 part in approximately 1500 to the height of the peak of the other. When a low-resolution mass spectrometer is used for making isotope analyses, overlapping of mass peaks due to impurities can result in appreciable errors. With the higher resolution of a double-focusing mass spectrometer, these errors can be minimized. Of course, the resolution can be adjusted to the desired degree by suitable adjustment of the slitwidths in the instrument.

Instruments of this type will undoubtedly prove useful in the field of gas analyses in the future. Molecules having the same mass numbers but differing in weight by an amount determined only by the difference in binding energies of the nuclear particles can be clearly resolved as in this example. Extension of the use of the instrument to the resolution of heavy hydrocarbons should prove fruitful.

Calculation of atomic weights. Chemists have long been interested in the relative combining weights of elements. Every 2 years a Commission on Atomic Weights, meeting as part of the International Union of Pure and Applied Chemistry, prepares a report on current work and recommends atomic weights for

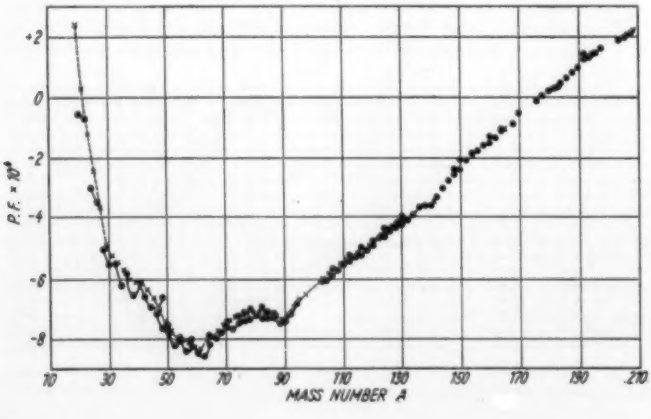

Fig. 5. Packing-fraction curve for stable atoms in mass range 10 to 210. Dashed line is through odd mass atoms; solid lines are through even mass atoms for each element.

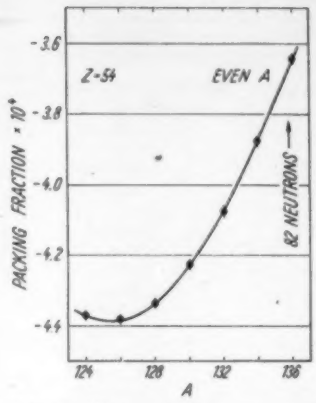

Fig. 6. Packing-fraction curve for even mass isotopes of a typical even atomic number element (xenon in this case). Curve shown is a parabola fitted to the experimental points by the method of least squares.

all the elements. In the 1953 report, 10 changes of atomic weights are recommended—some rather substantial—based on the results of mass spectroscopy and nuclear physics.

That there should have been some reluctance in the past in adopting physically determined values for atomic weights is understandable. Many of the early mass-spectroscopic measurements were in error. However, the art of measurement has so improved in recent years that this is no longer the case.

Masses of the very light elements can be determined either by mass spectroscopy or from nuclear-reaction data. Most of the points shown in Fig. 5 are the results of mass spectroscopy. Isotope abundances have been found by means of density measurements and optical or microwave spectra. However, most of the best values for relative abundances of isotopes are the determinations of mass spectroscopy.

Table 2 gives a comparison between the atomic weights of elements as adopted in 1953 by the International Union of Pure and Applied Chemistry and the values computed from physical measurements alone. The physical values are all based on the results of mass spectroscopy or nuclear physics.

Chemical atomic weights determined from measurements of the masses of individual isotopes and the relative abundances of isotopes can be in error because of four different effects.

1) The conversion factor between physical and chemical scales. Oxygen has three naturally occurring isotopes with mass numbers 16, 17, and 18. On the physical scale of atomic weights, the mass of O^{16} is assumed to be exactly 16.0000. Nuclear reaction data (*10*) give a mass of 17.004533 ± 7 for O^{17} and 18.004857 ± 23 for O^{18}.

The mean atomic weight for oxygen, of course, depends also on the relative abundance of these three isotopes. Unfortunately, there is considerable variation in the composition of samples taken from various sources. For an atmospheric sample, I (*11*) give percentage abundances as follows: O^{16}, 99.759 percent; O^{17}, 0.0374 percent; and O^{18}, 0.2039 percent. The O^{18} content in water and iron ores may be as much as 4 percent lower, and more recent work indicates a possibility of even larger variations in some special cases (*12*).

As a result, the mean atomic weight and, correspondingly, the conversion factor from physical to chemical scales, show some variation. For atmospheric oxygen, the physical weight is 1.0002783 ± 5 times greater than the chemical weight, whereas for oxygen from water, the factor is approximately 1.000268. In Table 2 it was arbitrarily decided to use 1.000275 in conformity with the practice followed by the Commission on Atomic Weights, although the evidence indicates that the mean value of 1.000273 ± 5 might better have been used.

In the few cases where its contribution was important, the associated uncertainty was taken to be 5 parts in 1 million.

2) Accuracy of isotopic mass measurements. Present mass-spectroscopic techniques have been developed to the point where isotopic masses can generally be determined with an uncertainty of not more than 1 part in 200,000, and frequently less. Both spectrographs and spectrometers are in active use, and some instruments now under construction may well improve even this high order of precision.

As is mentioned in preceding paragraphs, many of the lighter masses have also been calculated from accurately known nuclear-reaction data. These yield about the same accuracy, and, although small differences are present, the two methods agree remarkably well (see Table 1).

In cases where no reliable measurements have been

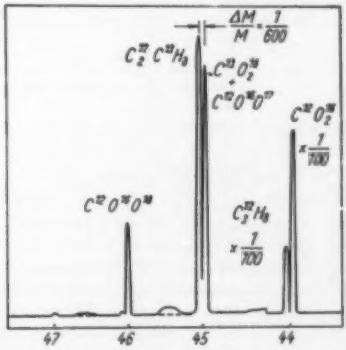

Fig. 7. Mass spectrum in region of CO_2 for a mixture of CO_2 and C_3H_8. In this case the slits in the double-focusing mass spectrometer described in reference 1 have been widened so that the measurement of a relative abundance of ions will be facilitated. Slit widths were $S_1 = 0.125$ mm, $S_2 = 0.5$ mm, $S_3 = 3$ mm, and $S_4 = 0.150$ mm. The broad peaks occurring between masses 46 and 47 and between masses 45 and 46 are artifacts, unexplained at the moment, and probably due to some misadjustment in the apparatus at the time the spectrum was taken.

Table 2. Atomic weights of the elements.

Atomic number	Element	1953 international value*	Computation from physical measurements	References	
				Isotopic mass	Relative isotopic abundance†
1 H	Hydrogen	1.0080	1.00801 ± 5[a,c]	L-1	†
2 He	Helium	4.003	4.00277 ± 4[m,c]	L-1	A-1
3 Li	Lithium	6.940	6.941 ± 2[v]	L-1	†
4 Be	Beryllium	9.013	9.0126 ± 1[c,m]	L-1	
5 B	Boron	10.82	10.82 ± 1[v]	L-1	T-1
6 C	Carbon	12.011‡	12.0115 ± 4[v]	L-1	N-1
7 N	Nitrogen	14.008	14.00733 ± 10[c,a,m]	L-1	N-1
8 O	Oxygen	16			
9 F	Fluorine	19.00	18.9992 ± 2[m,c]	L-1	
10 Ne	Neon	20.183	20.172 ± 10[a]	L-2	N-2
11 Na	Sodium	22.991‡	22.9908 ± 2[m,c]	L-2	
12 Mg	Magnesium	24.32	24.313 ± 7[a]	L-2	W-1
13 Al	Aluminum	26.98‡	26.9827 ± 2[m,c]	L-2	
14 Si	Silicon	28.09‡	28.086 ± 1[a]	L-2	N-8, W-2, I-1
15 P	Phosphorus	30.975‡	30.9750 ± 2[m,c]	L-2	
16 S	Sulfur	32.066‡	32.067 ± 3[v]	C-1	T-2
17 Cl	Chlorine	35.457	35.462 ± 8[a]	C-1	N-3
18 A	Argon	39.944	39.949 ± 1[a]	C-1	N-1
19 K	Potassium	39.100‡	39.103 ± 2[a]	C-1, J-1	N-1
20 Ca	Calcium	40.08	40.080 ± 1[a]	C-1, J-1	N-4, W-1
21 Sc	Scandium	44.96‡	44.9577 ± 4[m,c]	C-1	
22 Ti	Titanium	47.90	47.876 ± 3[a]	C-2, J-2	N-4
23 V	Vanadium	50.95	50.944 ± 1[c,m]	C-2, J-2	H-4, L-4
24 Cr	Chromium	52.01	52.000 ± 3[a]	C-2, J-2	W-1
25 Mn	Manganese	54.94‡	54.9407 ± 5[m,c]	C-2	
26 Fe	Iron	55.85	55.849 ± 1[a]	C-2	V-1, W-1, H-6
27 Co	Cobalt	58.94	58.935 ± 1[m,c]	S-2	
28 Ni	Nickel	58.69	58.712 ± 2[a]	C-2	W-1
29 Cu	Copper	63.54	63.550 ± 5[a]	C-2	B-1
30 Zn	Zinc	65.38	65.390 ± 5[a]	C-2	H-5, L-5
31 Ga	Gallium	69.72	69.725 ± 4[a]	C-3	I-2
32 Ge	Germanium	72.60	72.632 ± 6[a]	C-3	I-3
33 As	Arsenic	74.91	74.9251 ± 6[c,m]	C-3	
34 Se	Selenium	78.96	78.99 ± 1[a]	C-3	W-1
35 Br	Bromine	79.916	79.910 ± 2[a]	C-3	W-2
36 Kr	Krypton	83.80‡	83.808 ± 1[a]	C-3	N-2
37 Rb	Rubidium	85.48	85.472 ± 2[a]	C-3	N-2
38 Sr	Strontium	87.63	87.621 ± 3[a]	C-3	N-5
39 Y	Yttrium	88.92	88.910 ± 1[c,m]	C-3	
40 Zr	Zirconium	91.22	91.228 ± 5[a]	C-3, G-1	W-1
41 Nb	Niobium	92.91	92.910 ± 1[c,m]	C-3	
42 Mo	Molybdenum	95.95	95.89 ± 4[a]	D-1, D-3, D-4, G-1	W-2
43 Te	Technetium	(99)‖			
44 Ru	Ruthenium	101.1‡	101.07 ± 1[a]	H-1	F-1
45 Rh	Rhodium	102.91	102.909 ± 2[m,c]	n	
46 Pd	Palladium	106.7	106.44 ± 3[a]	H-3	S-3
47 Ag	Silver	107.880	107.88 ± 1[a]	n	W-1
48 Cd	Cadmium	112.41	112.429 ± 6[a]	H-3	L-5
49 In	Indium	114.76	114.824 ± 2[a]	H-3	W-1
50 Sn	Tin	118.70	118.747 ± 13[a]	H-3	H-6, H-10, W-1
51 Sb	Antimony	121.76	121.76 ± 1[a]	n	W-1
52 Te	Tellurium	127.61	127.634 ± 5[a]	H-3	W-1, W-2
53 I	Iodine	126.91‡	126.910 ± 1[m,c]	H-3	
54 Xe	Xenon	131.3	131.298 ± 2[a]	H-3	N-2
55 Cs	Cesium	132.91	132.912 ± 3[m]	Estimated	
56 Ba	Barium	137.36	137.335 ± 7[a,m]	H-2	N-5
57 La	Lanthanum	138.92	138.911 ± 3[m]	Estimated	I-4, I-5
58 Ce	Cerium	140.13	140.121 ± 7[a,m]	D-5, H-2	I-5
59 Pr	Praseodymium	140.92	140.912 ± 2[m]	H-2	
60 Nd	Neodymium	144.27	144.25 ± 1[a]	D-5, H-2	I-7

Atomic number	Element	1953 international value*	Computation from physical measurements	References: Isotopic mass	References: Relative isotopic abundance†
61 Pm	Promethium	(145)‖			
62 Sm	Samarium	150.43	150.35 ± 2[a]	H-2	I-3
63 Eu	Europium	152.0	151.97 ± 1[a]	Estimated	H-7
64 Gd	Gadolinium	156.9	157.262 ± 8[a]	H-2	H-7, L-6
65 Tb	Terbium	158.93‡	158.934 ± 5[m]	Estimated	
66 Dy	Dysprosium	162.46	162.506 ± 8[a, m]	H-2	I-6
67 Ho	Holmium	164.94	164.937 ± 5[m]	H-2	
68 Er	Erbium	167.2	167.268 ± 6[a, m]	H-2	H-8
69 Tm	Thulium	168.94‡	168.94 ± 1[m]	Estimated	
70 Yb	Ytterbium	173.04	173.044 ± 11[a, m]	Estimated	H-9, L-6
71 Lu	Lutetium	174.99	174.974 ± 7[a, m]	Estimated	H-8
72 Hf	Hafnium	178.6	178.50 ± 1[a]	H-2	H-6
73 Ta	Tantalum	180.95‡	180.947 ± 6[m]	Estimated	
74 W	Tungsten	183.92	183.856 ± 9[a, m]	D-2, D-5, G-1	W-2
75 Re	Rhenium	186.31	186.22 ± 1[a, m]	Estimated	W-1
76 Os	Osmium	190.2	190.25 ± 2[a, m]	H-2	N-6
77 Ir	Iridium	192.2‡	192.20 ± 3[a, m]	Estimated	S-1
78 Pt	Platinum	195.23	195.09 ± 1[a, m]	D-1, D-2, H-2	I-8, L-7
79 Au	Gold	197.0‡	196.975 ± 6[m]	Estimated	
80 Hg	Mercury	200.61	200.61 ± 1[m, s]	Estimated	N-2
81 Tl	Thallium	204.39	204.39 ± 2[a, m]	Estimated	H-6, W-1
82 Pb	Lead	207.21	207.22 ± 4[v]	H-2	N-7
83 Bi	Bismuth	209.00	208.987 ± 7[m]	H-2	
90 Th	Thorium	232.05	232.05 ± 1[m]	S-2	
92 U	Uranium	238.07	238.04 ± 1[m]	S-2	C-4, G-2

* *Comptes Rendus*, 17th conf., International Union of Pure and Applied Chemistry (1953), p. 93.

† A summary of all work on isotopic abundance through 1950 may be found in Bainbridge and Nier, "Relative Isotopic Abundances of the Elements," Preliminary Report No. 9, National Research Council, Washington, D. C. Wherever possible the references for Table 2 are to the original work on which the present calculations are based. Where more than one of the superscripts a, c, m, and v appear for a given element, they have been set down, whenever possible, in the order of their relative numerical contribution to the total uncertainty. In all cases the quoted uncertainty is intended to represent an estimate of the limit of error. When the original work gave only the probable error, this was, as a general rule, increased by a factor of 3 to 4.

[a] This uncertainty arises chiefly from the measurements of isotopic abundance.

[c] This uncertainty arises chiefly from the conversion factor 1.000275 ± 5 used in changing from the physical to the chemical scale of masses.

[m] This uncertainty arises chiefly from the mass measurements.

[v] This uncertainty arises from the known natural variation of isotopic abundance.

[s] These masses are obtained from unpublished calculations by T. L. Collins of this laboratory and are based on nuclear-reaction data from various published works.

‡ These values have been revised in recent years with consideration given to physical measurements.

§ Because of natural variations in the relative abundance of its isotopes, the atomic weight of sulfur has a range of ± 0.003.

‖ A value given in parentheses denotes the mass number of the isotopes of longest known half-life.

made, it is possible to interpolate the position of the isotope on the packing-fraction curve. Even if such an interpolation is in error by as much as one-half of a packing-fraction unit (which is highly unlikely), the resulting mass error is less than 1 part in the second decimal place (see thulium as an example).

3) Accuracy of relative isotopic abundances. In most cases, this source of uncertainty is by far the most serious. For some elements no measurements have been made since the development of precision techniques, and for others the available work shows sufficient lack of agreement to justify further investigation.

It is clear that these uncertainties do not affect single-isotope elements and have only a small effect on elements consisting of one abundant isotope and a few very rare isotopes. In such cases, mass and conversion-factor uncertainties are the only limitations.

4) Natural variations of isotope abundance. It is now well established that a variation of relative abundance occurs among the isotopes of a few elements, determined by the source from which the sample was taken. Oxygen has already been discussed as an example; sulfur is another and more dramatic case. Clearly, it becomes meaningless to speak of precision atomic weights for these elements, at least without specifying the exact sources from which they are obtained. Mass-spectroscopic techniques here serve only to indicate the range over which the atomic weight may be expected to vary.

In general, the agreement between the chemical and physical weights listed in Table 2 is quite good. Physical techniques clearly provide considerably greater precision whenever the atomic weight does not depend on relative abundance measurements. (Typical cases are single-isotope elements, such as scandium, and a few, such as vanadium, that have one over-

whelmingly abundant isotope.) New isotopic mass measurements are being published continuously, and it is to be expected that their accuracy will be even further improved by the instruments currently under construction.

For elements that have more than one abundant isotope, it is considerably more difficult to achieve such accuracy. Mass discrimination can occur both in the sample-handling system and within the instrument, partly because of small fractionation effects. It, therefore, requires the utmost care to reduce systematic errors below 1 percent, and only a few elements have been thus investigated. It should be noted that although much precise work has been done on isotope-abundance variations for a given element, one cannot always rely on their absolute accuracy. Finally, there are still some elements that have not been studied for many years, chlorine being a typical example. It is to be hoped that further work will soon be done along these lines, but for the present the chemical atomic weights are the most reliable in these cases.

References and Notes

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A new principle is an inexhaustible source of new views.—MARQUIS DE VAUVENARGUES.

Nuclear Binding Energies

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THE numerous atomic species or nuclides, which differ widely in their various properties, can be considered, whether they are formed in nature or whether they are produced artificially, as nuclear chemical compounds made of a few nuclear building stones, the so-called "nucleons." The first indication that this is so, as well as the first information concerning an important property of the nucleons—namely, their atomic weight—was given by the well-known law of integers of Aston. This law says that the weights of nuclides are practically integers, if they are expressed in atomic weight units. Naturally, the same also holds true for the sum of different nuclidic weights or, in other words, for the molecular weights of pure chemical compounds.

The fact that nuclidic weights are integers is the most striking feature in photographs of mass spectra; it is also the thing that makes these spectra so different from the patterns of optical spectra. Figure 1 shows sections of a photographic plate with a sequence of four mass spectra obtained in our mass spectrograph. The exposures were taken consecutively under otherwise constant conditions; only the time T of exposure was increased by a factor 3 each time, from 2 min 15 sec to 60 min 45 sec. A canal ray tube, into which a mixture of illuminating gas and air with a small amount of helium was introduced, served as an ion source, so that lines are present at almost every integer from the mass number $A = 4$ to the end of the plate at $A = 41$.

In the mass spectra with long exposure, one can also recognize lines between two integers, for example at $A = 13\frac{1}{2}$ or at $A = 13\frac{1}{3}$. But these also prove the law of integers, because they correspond to multiply charged ions, namely $^{27}Al^{++}$ (originating from the cathode of the discharge tube) and $^{12}C_2H_3^{++}$ or $^{40}A^{+++}$, respectively; since in the mass spectrograph one really determines the charge-to-mass ratio of the ions, multiply charged ions result in lines that correspond to one-half or one-third of their weight. The lines at $A = 6$, 7, and 8 also correspond to such doubly charged ions—namely, to those of the nuclides ^{12}C, ^{14}N, and ^{16}O, which are here the most abundant ones. Especially characteristic in the exposures of the sections of the plate reproduced in Fig. 1 are the two groups that start at $A = 12$ and at $A = 24$, respectively. The first contains, next to each other and partly superimposed, the isotopes of the elements C, N, and O and their hydrides—that is, the dissociation products of CH_4, NH_3, and OH_2. The second group is formed mainly by C_2 and its hydrides, that is, by the dissociation products of C_2H_6; at $A = 28$, the abundant molecular ions of CO and N_2 occur in addition, which makes this line appear particularly intense.

From the fact that their weights are integers, it was immediately concluded that the nuclides are built up from nucleons with an approximate atomic weight $A = 1$. Indeed, one would need only one type of nucleon if it were not well known that the nuclei of the neutral nuclides have electrons bound in their shells, again in integral numbers, corresponding to the atomic numbers in the periodic system. One must therefore conclude that the nucleon of weight $A = 1$ occurs in two manifestations or quantum states, once with a single positive charge as a proton and once uncharged as a neutron. The three nuclides $^{40}_{18}A$, $^{40}_{19}K$, and $^{40}_{20}Ca$, for example, which all happen to occur in nature, contain 40 nucleons each; but of these (according to the atomic number of these three elements indicated by the lower index) 18, 19, and 20, respectively, are protons, whereas the remainder, namely 22, 21, and 20, respectively, are assimilated as neutrons by the nucleus in question.

But the most interesting fact for our subject (*1*) is that Aston's law of integers can claim validity only as a more or less rough approximation. This, by the way, applies also to Lavoisier's law of chemistry. Even in ordinary chemistry the molecular weight of each exothermic compound must always be smaller than the sum of the atomic weights of the elements of which it is composed. In the process of compound formation, energy is released in the form of heat, and—according to Einstein's fundamental law of the equivalence of mass and energy—to each amount of energy there is a corresponding amount of mass, and vice versa. It has not yet been possible, of course, to measure the loss of mass ΔM, which corresponds to the binding energy (B.E.) in chemical reactions because, owing to the large conversion factor, this mass defect is extremely small. We have $B.E. = \Delta M \cdot c^2$, where c represents the velocity of light. The experimental situation is quite different, however, in the case of those binding energies that link the nucleons in nuclides. These nucleochemical binding energies surpass the ones in ordinary chemistry by a factor of about 1 million, and the corresponding loss of mass is therefore measurable in mass spectrographs of high resolving power.

The fact that Aston was able at all to state the law of integers proves something very strange. Indeed, each nucleon in its bound state must have an atomic weight of about 1.000—and this holds very nearly true for all nuclides heavier than about ^{16}O—but the atomic weights of the proton (neutralized as a hydrogen atom) and of the neutron amount to

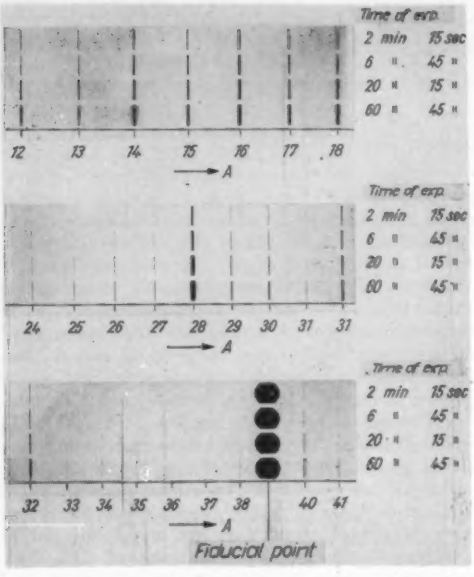

Fig. 1. Aston's law of integral mass numbers A. Sections of a photographic plate with mass spectra taken consecutively with increasing time T of exposure under otherwise unchanged conditions.

1.008 and 1.009, respectively. Each nucleon has therefore suffered the same average loss of mass of about 8.5 millimass units (mmu) in its bound state, or, expressed differently, the binding energy per nucleon has the same value, about 8 Mev in almost all nuclides, if we convert into the units of energy customary in nuclear chemistry (1 mmu = 0.931 Mev). If the mass defect per nucleon were not nearly constant for all nucleons above ^{16}O, or if it had a value different from the one just mentioned, then the nuclidic weights and the integers would get out of step for nuclides containing approximately 100 nucleons.

The binding of the nucleons in a large atomic nucleus is therefore quite similar to the binding of molecules in a condensed phase, such as a crystal or a liquid; that is, the total binding energy is, in first approximation, proportional to the number of molecules or of nucleons, respectively. This fact is the basis for the liquid-drop model of the nucleus. It is considerably substantiated by the result derived from other observations that the volume of the atomic nucleus is proportional to the number A of nucleons, or, to say it differently, the average density of the atomic nucleus remains constant for all nuclides throughout the whole periodic system. In addition, this result suggests that, in contrast to the situation existing in the atomic model, the material that forms atomic nuclei must be considered as rather similar to an ordinary liquid, in which the individual particles (nucleons) are packed closely together and maintain a constant density, independent of the size of the sample. One may therefore speak of a universal nuclear liquid that forms little droplets of various sizes and usually of spherical shape.

In 1927 Aston published his measurements of the deviations of the nuclidic weights from integers in the form of a packing fraction curve that reflects the variation of the binding energy per nucleon with the number A of nucleons in the various nuclides. In addition, the deviations from the constant value can be understood easily by means of the liquid-drop model. In heavy and large nuclei, there are, apparently, many more nucleons surrounded by others than there are in the light nuclei, where comparatively more nucleons are on the surface. In the light nuclei the (positive) surface tension per nucleon counteracts therefore the (negative) energy of cohesion. With a larger number of nucleons, the value of the binding energy per nucleon would be larger; the value for an infinitely large volume is reached asymptotically. In the case of heavy nuclei a different effect again has a loosening influence on the cohesion—namely, the Coulomb energy of the protons, which steadily increase in number and repel each other more and more. The binding energy per nucleon therefore reaches a maximum value in the neighborhood of $A = 60$. Considering energy alone, practically all heavy nuclei would be unstable against fission and all light nuclei would be unstable against fusion, but the reaction rates for these processes are so low that they are effectively zero. Fission produced by neutron capture by uranium and thermally induced fusion of hydrogen in the interior of stars (or on Bikini) can be considered exceptions.

The fusion of 4 nucleons to ^4He and the binding of ^4He onto ^{12}C, which results in the formation of the nuclide ^{16}O, liberates such a large amount of energy that the corresponding Einsteinian mass defect was already made visible in 1927 by Aston in the form of two neighboring but separated lines (doublet) for the molecular ion $^{12}CH_4$ and the atomic ion ^{16}O, both of mass number 16. Such a mass spectrum is reproduced in the bottom part of Fig. 2. After we, together with R. Herzog, had shown in 1934 how to calculate and build mass spectrographs according to ion-optical considerations, we were soon able (in 1938) to make photographs like the one shown in the middle of Fig. 2. It shows, in a subsequent enlargement, a picture of the same doublet that has now become a triplet by addition of the line $^{14}NH_2$, which divides the distance between the lines $^{12}CH_4$ and ^{16}O unequally. How far one can go with such enlargements and how accurately one can measure the distances between such multiplet lines and thus the mass equivalents of differences in the binding energy is finally limited only by the resolving power that can be attained. In our apparatus (*2*)—which in the last 20 years has undergone numerous improvements of a constructional and technical nature without any changes in the principle or even in the dimensions of the first arrangement—the resolving power now amounts to 100,000, that is two masses which differ by

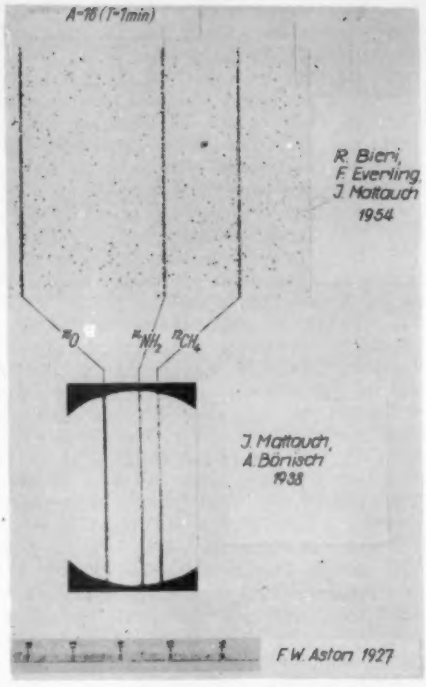

Fig. 2. Mass-spectrographic doublet ($^{12}C^1H_4 - {}^{16}O$) at $A = 16$. Showing the mass defect of the fusion of 4 nucleons to ^4He and the binding of ^4He onto ^{12}C leading to the formation of ^{16}O. Historically this is the first case of two well-resolved lines at the same mass number.

only 0.001 percent still appear as two separate lines. This corresponds in the middle of the plate to a line width of about 1 μ. The top part in Fig. 2 demonstrates the present state of the experimental technique. By means of such magnifications it is, of course, not possible to resolve unseparated lines or to add lines by magic; on the contrary, weak lines often disappear in the process.

Figure 3 shows in its lower part a multiplet at mass number 20, which we succeeded in obtaining in 1938 and which—today we might say unfortunately—was taken over by the authors of various textbooks. We find consolation in the thought that these books—for reasons that lie with the authors—are so popular that it will soon be possible to print the upper part of Fig. 3 in new editions. The advancement in resolving power can be seen not only in the larger number of resolved lines (10 instead of 6) but especially in the separation of the various heavy water molecules, for example. In the lower picture the line designated $^{18}OH_2$ appears as a weak, only poorly resolved satellite of the very intense line for $^{16}OD_2$. Today (upper picture of Fig. 3) the two are widely separated from each other, and in between them the very weak line for ^{17}ODH becomes visible. In 1938 we would not even have been able to exclude with certainty the possibility that the line designated as $^{18}OH_2$ was not produced partly by ^{18}OD also. Today the lines corresponding to these two molecular ions also appear separated by many times the line width. Naturally, one cannot hope to obtain in a case of 10 lines at the same mass number (we have sometimes obtained even more) all lines of the multiplet in equal intensity, especially if isotopic nuclides that are not at our disposal in 100-percent pure form are involved. For the remaining photographs I should like therefore to ask indulgence.

The simple liquid-drop model represents, surprisingly, many properties of the atomic nuclei very well. As is true of any model, its use should not, however, be stretched too far. As in the structure of the electron shell, which is so different in other respects, there appear certain closed shells in the process of building up the nuclei from nucleons. In the form of double and quadruple periodicities such filled shells were long known and even expected on the basis of the Pauli principle. Since we know that two kinds of nucleons exist, one charged and one uncharged, each of which can be built in with a spin of $+\frac{1}{2}$ or $-\frac{1}{2}$, there is always room for exactly 2, or even better, 4 nucleons (2 protons and 2 neutrons, each type with both spin orientations) in one shell. This is the reason why the formation of the ^4He-nucleus, which repre-

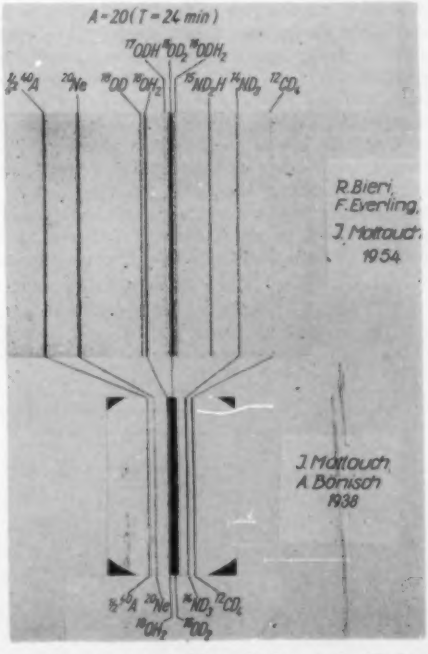

Fig. 3. Mass-spectrographic multiplet at $A = 20$ showing the increase in resolving power reached during the past 16 years.

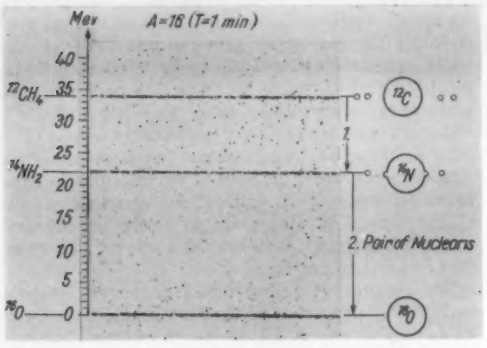

Fig. 4. Binding energies of successive pairs of nucleons leading from ^{12}C over ^{14}N to ^{16}O.

sents the first closed shell with 4 nucleons, yields the abnormally high energy of 28 Mev, an energy so high that to date we defray all our energy consumption on earth from it with the sole exception of the energy gained by nuclear fission.

In the last decade another type of closed shell has been reported in the papers of the Heidelberg group (Haxel, Jensen, and Suess) and also simultaneously by American scientists (Maria Goeppert-Mayer and others). These closed shells occur at certain proton and neutron numbers, which, at first, because an explanation was lacking, were designated as magic numbers. Filled shells are characterized by the appearance of a certain saturation of the enormously large binding forces that exist between the nucleons at small distances. Such nuclei show a definite disinclination to bind a new nucleon. The last nucleon that terminates the closed shell is bound, however, with an energy noticeably higher than the average. In an energy-level diagram the levels corresponding to the closed shells are therefore displaced slightly downward in comparison with the others. This can be illustrated with some of our multiplets, which if rotated

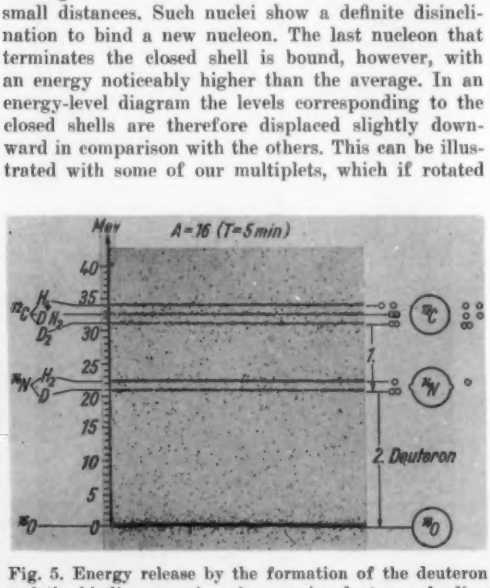

Fig. 5. Energy release by the formation of the deuteron and the binding energies of successive deuterons leading from ^{12}C over ^{14}N to ^{16}O.

by 90° represent nuclear energy-level diagrams, where instead of using the drawing pen, the mass spectrograph is used directly for drawing in the levels.

Figure 4 shows the triplet of Fig. 2 rotated 90° furnished with an energy scale and interpreted as an energy-level diagram. Special attention should be given to the nuclei indicated as large circles in the center of the rough model pictures on the right side, and one should interpret the chemically bound hydrogen atoms only as a far-distant "store" of nucleons from which we draw in order to build up the central nuclei further. In order to be able to interpret the photographs at all as energy-level diagrams, it is necessary to have enough nucleons in the "store" so that one is able to complete the nucleons of the central nuclei to the number A indicated on top of the photographs. We start with a multiple of ^4He—namely the ^{12}C nucleus—and we see that the building in of the first pair of nucleons liberates considerably less energy than the one of the second pair, which leads to the ^{16}O nucleus and therefore to a closed shell. In order to be accurate, we have to increase both mass differences ($^{12}CH_2 - ^{14}N$) and ($^{14}NH_2 - ^{16}O$) by the difference ($^1n - ^1H$) = 0.844 mmu = 0.786 Mev in order to obtain the correct mass equivalent of both energy amounts—12.5 and 22.9 Mev, respectively—because both times a proton has been "assimilated" as a neutron by the central nucleus, since obviously we can have only the chemically bound hydrogen atoms in the "store." The difference ($^1n - ^1H$) corresponds, however, in our photographs to approximately four to five line widths only and can be disregarded in a qualitative approach.

For the recording of the next energy-level diagram (Fig. 5) by the mass spectrograph we added deuterium gas to the discharge tube, so that all combinations might occur in the hydrides that can result through substitution of 1 D atom for 2 H atoms. The equidistant intervals ($^{12}CH_4 - ^{12}CDH_2$), ($^{12}CDH_2 - ^{12}CD_2$), and ($^{14}NH_2 - ^{14}ND$), increased, however, by the difference ($^1n - ^1H$), yield in each case the mass equivalent (quite small, by the way) of the binding energy of the deuteron (2.2 Mev). Here it can be seen clearly how, according to Einstein's law, the mass is reduced each time by the same amount, if fusion of 2 nucleons into 1 deuteron occurs in the "store." Furthermore, it is possible to read directly (arrows in the energy-level diagram) the energy amounts (10.3 and 20.7 Mev) that are released by the successive binding of preformed deuterons. The first energy amount is only half as large as the second.

The photographs for the remaining figures were achieved only with the help of samples that contained enriched amounts of the rare isotopes ^{13}C, ^{15}N, and ^{18}O (*3*). In Fig. 6 we are able to follow easily the binding of successive single neucleons to the central nucleus as well as the numerous fusions of nucleon pairs to deuterons in the "store." The mass equivalents of the corresponding binding energies are again marked in the diagram by arrows, and

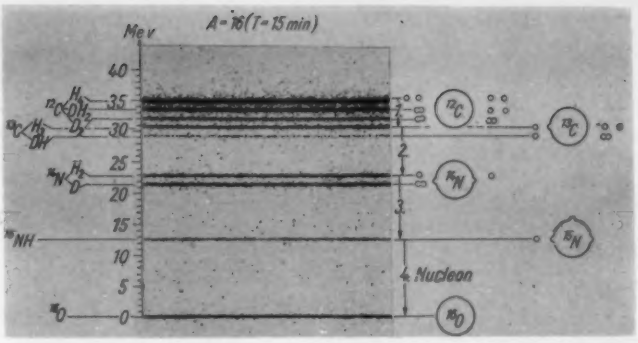

Fig. 6. Binding energies of successive nucleons in the sequence ^{12}C, ^{13}C, ^{14}N, ^{15}N, ^{16}O.

it can easily be seen that the first and the third each have to be increased by the difference $(^1n - ^1H)$ in order to obtain the correct result, for the first and the third arrows obviously combine isotopic nuclides. After the building in of each second nucleon a certain closed shell becomes apparent, for the even nucleons release considerably more energy than the preceding odd ones. The corresponding amounts are in the sequence of Fig. 6: 4.9_5 and 7.5_5 Mev as well as 10.8 and 12.1 Mev.

In Fig. 7 we are able to follow the same occurrence two mass units higher. The nucleon "stores" are everywhere increased by 2, if this is compatible with the chemical compounds. Again the picture is threaded through like a railroad yard by the standard gage parallel tracks so typical for the formation of deuterons, which can occur here in the "stores" of the nuclei ^{15}N and ^{16}O also. From the nucelus ^{12}C to the nucleus ^{16}O nothing was changed in the binding energies of successive deuterons and nucleons. Their amounts are identical with those that we obtained from the previous pictures. However, the closed shell at ^{16}O becomes very distinctive. This nucleus particularly is saturated and only little disposed to bind further nucleons. The next pair of nucleons, which leads to ^{18}O, consists of 2 neutrons built in with opposite spin. Its binding energy is given by the interval $(^{16}OH_2 - ^{18}O)$, which in this case has to be increased by twice the difference $(^1n - ^1H)$, in order to obtain the correct value of 12.2 Mev. It is somewhat smaller than the previous value for the binding energy of the nucleon pair taken from Fig. 4, which led from ^{12}C to ^{14}N.

The particular disinclination of the ^{16}O nucleus to bind even the very next nucleon is shown even more clearly in Fig. 8. The multiplet shown in Fig. 3 is prepared here as an energy-level diagram, and the pattern allows one to recognize in nearly all its details the building up of two successive shells of four. First of all we observe again the two deuteron steps leading from ^{12}C to ^{16}O, as shown in previous pictures. The interval between the two weak lines for $^{16}ODH_2$ (hydrides, not very familiar to the chemist but known for a long time to mass spectroscopists) and ^{17}ODH increased by the $(^1n - ^1H)$ difference gives the binding energy of the first neutron to the ^{16}O nucleus which represents the fifth nucleon, counting from ^{12}C. Its value—4.1 Mev—is smaller by 0.8 Mev than the corresponding value of the binding energy of the first neutron in the ^{12}C nucleus. The binding energy of the second neutron that leads to ^{18}O—that is, the step indicated in Fig. 8 as the sixth nucleon increased by the $(^1n - ^1H)$ difference—amounts to 8.1 Mev. It is approximately 0.5 Mev higher than

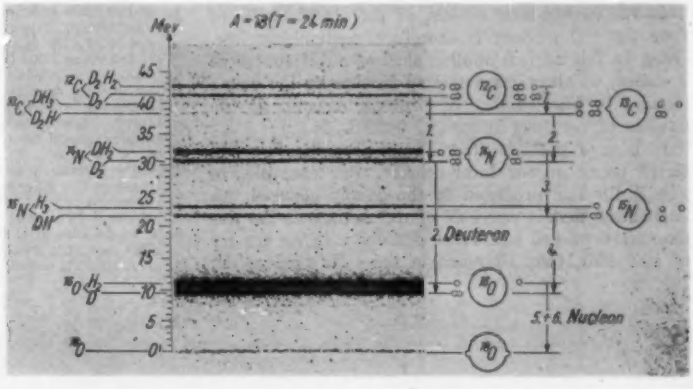

Fig. 7. Binding energies of successive deuterons and nucleons in the sequence that leads from ^{12}C over ^{16}O to ^{18}O.

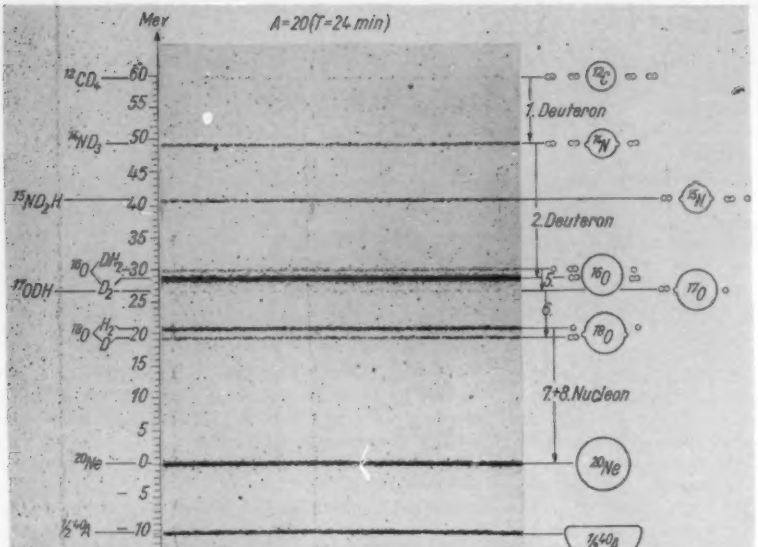

Fig. 8. Binding energies of successive deuterons and nucleons in the sequence that leads from ^{12}C over ^{16}O to ^{20}Ne.

the binding energy of the proton following ^{13}C, which leads to ^{14}N.

The subshell resulting from the building in of two neutrons with opposite spin is apparently better defined. The difference ($^{18}OH_2 - ^{20}Ne$) yields directly a value of 20.8 Mev for the binding energy of the now following proton pair. It is 1.1 Mev smaller than the corresponding energy of the nucleon pair, which leads from ^{14}N to ^{16}O. One recognizes the loosening up that is brought about by the electrostatic repulsion of the two protons. Hence, the sum of the binding energies of the four nucleons, which leads from ^{16}O to ^{20}Ne, is 2.4 Mev smaller than the one for the first four nucleons which follow the ^{12}C nucleus. Whereas the ^{12}C nucleus fuses the first alpha particle (thereby becoming ^{16}O) with a binding energy of 7.15 Mev, the ^{16}O nucleus is able to bind the next alpha particle (leading to ^{20}Ne) with an energy of only 4.75 Mev.

In the energy-level scheme of the closed shells of four the ^{16}O nucleus is therefore particularly low-lying. In this nucleus another shell of a different type is closed, which is characterized further by the magic number 8. The number of protons, as well as the number of neutrons in the ^{16}O nucleus, is 8.

It is also possible that lines below the "ground state" occur in our level scheme. For example, in Fig. 8, the line produced by the doubly charged ^{40}A ions shows that in one-half of a ^{40}A nucleus the nucleons are packed still more densely with an energy of 10.5 Mev, than they are in the ^{20}Ne nucleus. In the ^{40}A nucleus the binding energy per nucleon is therefore on the average about 0.5 Mev larger than it is in the ^{20}Ne nucleus.

In view of some small but definite discrepancies in the masses of some substandards with respect to which most nuclidic weights are measured, and on the accurate value of which in relation to the standard ^{16}O various groups of physicists have not been able to agree upon, I would like to mention that we have tried particularly to increase the accuracy of these measurements. In a paper (*4*) just published we were able to measure such substandards with an error of 1 in 3 million, and we hope with photographs, some of which are shown here, to reach an accuracy of 1 in 10 million.

References and Notes

1. This article is based on a lecture given at the meeting of the German Bunsen Society for Physical Chemistry in Bayreuth, 28 May 1954. It was first published in *Z. Elektrochem.* **58**, (1954) and is reprinted here by permission. I am indebted to Mrs. A. M. Akeley and H. Paul, Purdue University, for the translation of the manuscript.
2. A detailed description of the double focusing mass spectrograph which we are now using and with which the photographs shown here were made will appear shortly in the *Z. Naturforsch.* I would like gratefully to acknowledge the enthusiastic help of my two young collaborators, R. Bieri and F. Everling, who are largely responsible for the technical improvements of the apparatus and the taking of the photographs.
3. I would like to express my thanks to K. Clusius for the first two; the latter we received from Harwell.
4. J. Mattauch and R. Bieri, *Z. Naturforsch.* **9a**, 303 (1954).

News and Notes

Preliminary Announcement of Atlanta Meeting

The 122nd meeting of the American Association for the Advancement of Science, the annual meeting for the year 1955, will be held in Atlanta, Ga., 26–31 Dec. This will be the first time that the AAAS has met in the South since the 1941 meeting in Dallas—and the first time in the Southeast since the Richmond meeting of 1938. In the intervening years, the Association's annual convention has increased in size but, fortunately, the physical facilities of Atlanta have also increased so that it is again possible to meet in this part of the nation. (There have been eight AAAS meetings in the South: Charleston, S.C., 1850; Nashville, 1877; New Orleans, 1905; Atlanta, 1913; Nashville, 1927; New Orleans, 1931; Richmond, Va., 1938; and Dallas, 1941.) The Association returns to Atlanta after an interval of 42 years.

The four decades since the first Atlanta meeting in 1913 have witnessed a veritable revolution in nearly every aspect of science and society. Agriculture has become much more diversified and on an increasingly scientific basis, and great industries have multiplied and developed. A marked increase in the production of natural gas and electric power, added to abundant natural resources of water and minerals, have resulted in commensurate increases in original industries, such as steel, sulfur, fertilizers, and naval stores, and in a host of new developments. Many of the nation's largest and most modern oil refineries, pulp and paper mills, chemical plants, and textile mills, processing both natural and synthetic fibers, are in the southern states.

There have been advances in medicine and public health. Southern schools, colleges, and universities have expanded and improved to keep pace with the demands for well-trained graduates. The volume of research has steadily increased. In recent years, great atomic energy projects at Oak Ridge, Tenn., and elsewhere have begun to have a profound effect on southern science and technology.

Atomic energy. It is logical that this 122nd meeting of the Association will focus the nation's attention on the South's present status and future potentials and will bring to the region the newest developments in all fields of science. One instance of this will be a four-session symposium, "Atomic energy and agriculture," sponsored jointly by the Oak Ridge Institute of Nuclear Studies and the Association. This symposium, as planned by a committee headed by Cyril L. Comar, principal scientist, medical division, ORINS, will comprise a critical and realistic survey of the use of radioisotopes in the agricultural sciences—including unsolved problems, anomalies, and potentials.

The four parts of the symposium are as follows: (i) Soil-plant relationships—chairman, Nathan S. Hall, biology and medicine division, U.S. Atomic Energy Commission. Included: soil chemistry and fertility, soil testing, micronutrients, soil physics, and soil-root relationships. (ii) Plant metabolism—chairman, Harold B. Tukey, Michigan State University. Included: foliar absorption, translocation, photosynthesis, nitrogen metabolism, and plant regulators. (iii) Animal metabolism—chairman, Homer Patrick, University of Tennessee. Included: micronutrient metabolism, macronutrient metabolism, lactation and hormones, and amino acids-sulfur metabolism. (iv) Food sterilization—cochairmen, G. A. King, Nutrition Foundation, and B. F. Trum, Veterinary Corps, U.S. Army, assigned to AEC, Oak Ridge. Included: bases of radiation sterilization, isotope availability and use, design of facilities, biochemical problems, acceptance of radiated foods, present status and feasibility of radiation sterilization. The speakers will be recognized experts from all parts of the nation. The entire program, planned for a large audience, is coordinated with the research conference on "Use of isotopes in agriculture" to be held 12–14 Jan. 1956 at Michigan State University under the auspices of the Council of Participating Institutions of the Argonne National Laboratory.

International Geophysical Year. [*Science* **119**, 569 (1954)]. The International Geophysical Year—really 18 months, 1 July 1957 to 31 Dec. 1958—will transcend the previous International Polar Years of 1882–83 and 1932–33 in that it covers the whole globe, includes many more scientific disciplines, and will have the concerted efforts of the scientific organizations of some 40 nations. The AAAS Atlanta meeting will include the first, and probably only, program open to the general scientific public on the scope of the scientific programs of the U.S. National Committee for the IGY. The three sessions of the IGY symposium (Joseph Kaplan and Hugh Odishaw as program chairmen), sponsored jointly by the AGU, NRC, NSF, and the AAAS, will outline the problems and observations to be made in cosmic rays and solar terrestrial effects; ionospheric physics, aurora and airglow; geomagnetism; meteorology; oceanography; glaciology; and seismology. Speakers on these phases will come from various parts of the country.

Crisis in Science Education. At its meeting on 8 May, the recently established Committee on AAAS Meetings (Leonard Carmichael, Bernard D. Davis, John E. Ivey, Jr., Harry C. Kelly, and Howard M. Phillips) agreed that AAAS meetings should include and emphasize programs that are of importance to science as a whole. The committee decided that the Atlanta meeting should include consideration of the serious situation, in the United States today, of too few college students who elect majors and graduate work in the sciences and engineering and the related problem of the growing shortage of qualified science teachers at both the high-school and the college level.

The problem is of such general significance that a

special session—for the AAAS as a whole—will be held on the morning of 29 Dec. Speakers of national eminence will survey the steps that must be taken and the contributions that can be made by national organizations, federal and state agencies, industry, and educational institutions. AAAS sections will not hold sessions on that morning, and the participating societies will be asked to clear it also, if at all possible, so that all may be able to attend. All AAAS affiliates and interested agencies and institutions are invited to send delegates to this session. AAAS Council Meeting II on 30 Dec. will be devoted largely to what organized science can do as a major contribution to this emergency.

Participating societies. The annual national meetings of the following will be held with the AAAS:

- Academy Conference
- American Association of Clinical Chemists
- American Nature Study Society
- American Phytopathological Society
- American Society of Parasitologists
- National Association for Research in Science Teaching
- National Association of Biology Teachers
- Society for the Advancement of General Systems Theory
- Society of Systematic Zoology

Societies that have scheduled regional meetings are

- American Academy of Forensic Sciences
- American Geophysical Union, Southeastern Section
- American Association of Hospital Consultants
- American Meteorological Society
- American Physiological Society
- American Psychiatric Association
- American Society of Plant Physiologists, Southern Section
- Association of Southeastern Biologists
- Botanical Society of America, Southeastern Section
- Ecological Society of America
- Herpetologists League
- National Academy of Economics and Political Science
- National Association of Science Writers
- National Science Teachers Association
- National Speleological Society
- Society for the Advancement of Criminology
- Society for Research in Child Development

Other organizations that have planned special programs are

- AAAS Cooperative Committee on the Teaching of Science and Mathematics
- Alpha Chi Sigma
- Alpha Epsilon Delta
- Conference on Scientific Editorial Problems
- Conference on Scientific Manpower
- National Geographic Society
- Scientific Research Society of America
- Sigma Pi Sigma
- Society of the Sigma Xi
- United Chapters of Phi Beta Kappa

Center of the meeting. The recently enlarged Atlanta Municipal Auditorium will be the focal point of the meeting. Located within a few blocks of the downtown hotels, it will house (i) the AAAS Main Registration and Information Center; (ii) the Visible Directory of Registrants; (iii) the AAAS Science Theatre; (iv) the Annual Exposition of Science and Industry; (v) a number of sessions; and (vi) the Biologists' Smoker (open to all registrants), 29 Dec. Immediately across the street are the classroom buildings of the Atlanta Division of the University of Georgia where there will be a lounge and where many other sessions will be held.

AAAS headquarters hotel will be the much enlarged Dinkler Plaza. Other "downtown" hotels—all of them close together and near the auditorium—are the Atlantan, Georgia, Hampton, Henry Grady, Imperial, Jefferson, Peachtree on Peachtree, and Piedmont. Some of these will house sessions and, collectively, they afford a substantial number of sleeping rooms at a wide range of rates.

A second center of the meeting will be the Hotel Atlanta Biltmore area about 1½ miles due north of the downtown center—readily reached by trackless trolleys along Peachtree Street. Other hotels close by are the Cox-Carlton, Georgian Terrace, and Peachtree Manor. There will be sessions in the Biltmore and on the nearby campus of the Georgia Institute of Technology.

The facilities of Atlanta University, 1 mile west of the downtown hotels, have also been offered to the Association, and several sessions—notably the AAAS presidential address by Warren Weaver and the reception that follows—will be held here 28 Dec. Special buses will facilitate traffic between the hotels and Atlanta University that evening and daily between the hotels and the Auditorium.

The parasitologists will have an afternoon of demonstrations in the biological laboratories at Emory University, and an open house for visiting biologists may be scheduled.

Housing. Housing accommodations are adequate, but, as in all cities, single rooms are relatively scarce and double rooms used for single occupancy cost more. Sharing a room with a colleague or friend is strongly recommended. It is anticipated that dormitory units at both Georgia Tech and Atlanta University will be available. Detailed housing information and a coupon for room reservations will begin to appear in *Science* and *The Scientific Monthly* in July, at which time the headquarters of each section and participating society will be announced.

Advance registration. Advance registrants will receive the General Program-Directory early in December by first-class mail. Coupons will appear in AAAS journals beginning in July.

The Programs

A—Mathematics

Details of the program of Section A are not yet available, but it is probable that the sessions will come early or late within the period 26–31 Dec., so that it will be possible for mathematicians to attend also the meetings of the mathematical societies at Houston.

B—Physics

Section B (J. H. Howey, program chairman) will have sessions for invited papers on pure and applied physics—for example, radiation measurements—on graduate research programs, and on the teaching of physics. The Physicists' Dinner will be sponsored jointly with *Sigma Pi Sigma*, which will also arrange the symposium, "The role of physics in premedical education," cosponsored by Alpha Epsilon Delta. The *American Meteorological Society* (Seymour Hess, program chairman) will hold its 142nd national meetings at Atlanta and will also cosponsor the AGU program. In addition to arranging the afore-mentioned four-session symposium, "Atomic energy and agriculture," the *Oak Ridge Institute of Nuclear Studies* will cosponsor the symposium, "Some peaceful uses of atomic energy" of the National Academy of Economics and Political Science.

C—Chemistry

Section C (Robert S. Ingols, program chairman) will have three or four sessions for contributed papers, 27, 28, and 31 Dec.; a two-session symposium, "Effect of chemical agents on biological organisms"—not a catalog of reactions but an attempt to understand the mechanisms of the responses, 28 Dec.; a symposium, "Sedimentary kaolins along the southeastern fall line," including origin, processing, mineralogical studies, uses in paper industry, ceramics, and so on, 29 Dec.; a two-session symposium, "Radiation chemistry," 30 Dec.; and a vice-presidential address by Ingols and Chemists' Dinner, 29 Dec.

Alpha Chi Sigma will sponsor a Chemists' Luncheon, and it is anticipated that the *American Chemical Society, Georgia Chapter*, will hold its December meeting with the AAAS. The *American Association of Clinical Chemists* (Albert Edward Sobel, program chairman) has arranged a symposium, "Recent concepts in clinical chemistry," and a dinner, 26 Dec.; and two sessions for contributed papers in clinical chemistry, 27 Dec.

D—Astronomy

Section D's program, in process of arrangement, will include a vice-presidential address by Gerald M. Clemence.

E—Geology and Geography

Section E (Robert L. Nichols, secretary) will have concurrent sessions for contributed papers in geology and geography, one or more symposia, a smoker, and a vice-presidential address by Wallace W. Atwood, Jr.—with appropriate portions of its program cosponsored by the *Geological Society of America* and the *Association of American Geographers, Southeastern Division*. The *National Geographic Society* will have its usual excellent lecture and accompanying film. The *National Speleological Society* is planning a session for contributed papers, 27 Dec. and may have an additional joint program with the *Georgia Minerals Society*.

F—Zoological Sciences

The program of Section F (J. Gordon Carlson, program chairman) includes sessions for contributed papers in all fields other than systematic zoology and parasitology, 26, 27 Dec.; demonstrations, a Zoologists' Dinner, and vice-presidential address by Carlson, 29 Dec.; and a two-session symposium, "Formation and early development of the embryo," organized by R. C. von Borstel with Albert Tyler as chairman, 30 Dec. Egg formation, fertilization, and various physiological and cytological aspects will be considered. Speakers include E. J. Dornfeld, Oregon State; W. S. Vincent, State University of New York Upstate Medical Center; C. B. Metz, Florida State; A. Monroy, University of Palermo, Italy; J. R. Gregg, Columbia University; W. E. Berg, University of California, Berkeley; R. C. von Borstel, Oak Ridge National Laboratory; and Albert Tyler, California Institute of Technology. Section F is cosponsoring the symposia, "The species concept" of the Association of Southeastern Biologists, "Applications of immunochemistry to biological research" of the Society of General Physiologists, and "Atomic energy and agriculture," part III.

The national annual meeting of the *American Society of Parasitologists* (A. C. Walton, secretary) comprises five sessions for contributed papers, 28–30 Dec.; and a presidential address, annual luncheon, a business meeting, and demonstrations, 29 Dec. The *Herpetologists League* (James A. Fowler, program chairman) plans three sessions for papers, 28 and 29 Dec., and an all-day field trip, 30 Dec. The national annual meeting of the *Society of Systematic Zoology*, following the pattern of former meetings with the Association, will have sessions for contributed papers, one or more symposia or panels, evening lectures, and a business meeting. A feature will be the annual exhibition of the SSZ Library.

FG—Biological Sciences

The special program of the *Association of Southeastern Biologists* (Mary Esther Gaulden, program chairman) will include a meeting of the executive committee, 27 Dec.; a breakfast, 28 Dec.; and three symposia. The first of these, "The species concept," of broad interest to all biologists, is jointly sponsored by AAAS Sections F and G and the ASB and will be cosponsored by a number of other societies. Its two sessions, 29 Dec., will present the points of view of the taxonomist, paleontologist, bacteriologist, protozoologist, parasitologist, ecologist, biochemist, cytologist, and geneticist. The society will cosponsor "Formation and early development of the embryo," outlined under Section F, and "Applications of immunochemistry to biological research" of the *Society of General Physiologists*. This latter symposium, organized by Norman G. Anderson, with H. R. Wolfe as chairman, which will be held on 29 Dec., will include antibody production, preparation of cellular antigens, agar diffusion techniques, and applications to specific problems. The SGP, in addition, may have a session for contributed papers.

The *Ecological Society of America* (Eugene P. Odum, program chairman) plans a program—jointly, in part, with the Botanical Society of America, Southeastern Section (Robert B. Platt, program chairman)—that will include exhibits of ecological instrumentation, of interest to both physical and biological scientists; a field trip to Stone Mountain; and sessions for contributed papers jointly with Sections F and G. The annual national meeting of the *National Association of Biology Teachers* (John P. Harrold, program chairman) begins with a business meeting, 26 Dec.; includes three joint morning sessions with the ANSS and NSTA and three afternoon sessions, 27–29 Dec.; and concludes with an all-day field trip, jointly with ANSS, 30 Dec.

G—Botanical Sciences

Section G (Barry Commoner, secretary) is planning a two-session symposium that will deal in an integrated fashion with the economic, technologic, physiological, and biochemical aspects of "The tobacco plant" and "The cotton plant," 27 Dec. There will be two or more sessions for contributed papers, probably jointly with the *Botanical Society of America, Southeastern Section,* 28 and 29 Dec.; and a Botanists' Dinner and vice-presidential address by Lawrence R. Blinks, 29 Dec. Among the symposia that Section G will cosponsor are "Atomic energy and agriculture" and "The species concept."

The program of the annual national meeting of the *American Phytopathological Society* (Glenn S. Pound, secretary) includes three council meetings, 27 Dec.; two general business meetings, 28 and 30 Dec.; seven series of four concurrent sessions for papers, 28–30 Dec.; a symposium, "Plant pathologists can use television," 28 Dec.; and the Phytopathologists' Banquet, 29 Dec. The meeting will be held jointly with the annual meeting of the *APS, Southern Division.*

The *American Society of Plant Physiologists, Southern Section* (Aubrey W. Naylor, program chairman) is arranging a two-session symposium, "The mechanism of action of plant growth substances" that will be cosponsored by Section G.

I—Psychology

Section I (William D. Neff, secretary) has scheduled five sessions of invited papers on the following subjects, arranged as indicated: "The status of military psychology, 1955," Wilse B. Webb, 27 Dec.; "Recent studies of the sensory processes," John F. Hahn, and "The brain and behavior," Harlow W. Ades, 28 Dec.; "Learning," Stanford C. Erickson, and "Primate behavior," Arthur J. Riopelle, 29 Dec. The vice-presidential address by S. S. Stevens will be given 27 Dec., and there will also be sessions for contributed papers. The *Society for Research in Child Development* will hold a regional meeting at Atlanta.

K—Social and Economic Sciences

Section K (Donald P. Ray, secretary) will have one or more symposia centering on varying phases of the economic development of the South and probably another on political trends in the region. There will be a vice-presidential address by Conrad Taeuber. The section will cosponsor the program of Section P; Section M's symposium, "Orthopedic appliances and the economics of rehabilitation"; and the symposium, "Some peaceful uses of atomic energy," of the *National Academy of Economics and Political Science,* which is also cosponsored by *Pi Gamma Mu.*

L—History and Philosophy of Science

Section L (Jane M. Oppenheimer, secretary) will have a full program of sessions for invited and contributed papers and a vice-presidential address by Raymond J. Seeger, "Man and science." The symposia planned are "Mathematics and biology," "The sociology of science," "Science and the humanities," and "Creativity in science," all cosponsored by appropriate AAAS sections. The *Philosophy of Science Association* will cosponsor a portion of the section's program, as also will the *Southern Society for Philosophy and Psychology.* The recently organized *Society for the Advancement of General Systems Theory* (L. von Bertalanffy, executive secretary) has scheduled two afternoon sessions for contributed papers.

M—Engineering

Section M (M. J. Goglia, program chairman) plans a symposium that will be of wide interest to all fields of engineering—automation. A second symposium on "Orthopedic appliances and the economics of rehabilitation," with accompanying exhibits, arranged by Eugene F. Murphy and cosponsored by Sections K and N, will be held 30 Dec.; speakers include Robert L. Bennett, Augustus Thorndike, Eugene F. Murphy, Anthony Staros, W. Frank Harmon, McCarthy Hanger, Jr., Grace M. Fraymann, and Donald H. Dabelstein.

N—Medical Sciences

As in previous years, Section N (S. E. Luria, program chairman) will have a four-session symposium, the participants of which will come from all parts of the nation. This year's subject, "Microbiology and medical research," scheduled for 27 and 28 Dec., includes (i) "Nutrition of microörganisms," (ii) "Metabolic aspects of medical microbiology," (iii) "Radiation effects in microbiology," and (iv) "Chemotherapy." The fourth session will include the vice-presidential address of Luria, the 11th presentation of the Theobald Smith Award of Eli Lilly and Company, and the first presentation of the new AAAS-Anne Frankel Rosenthal Memorial Award for Cancer Research.

Alpha Epsilon Delta (Maurice L. Moore, national secretary) will have its customary annual luncheon and meeting with the AAAS, 28 Dec., with William McGlothlin of the Southern Regional Education Board speaking on "Problems of medical and dental education in the southern area." The society will cosponsor the symposium, "The role of physics in premedical

education," of Sigma Pi Sigma. The *American Academy of Forensic Sciences* will have a program of interest to its members and others in the medical-legal professions.

The *American Association of Hospital Consultants* (Jack Masur, program chairman), will have its usual special symposium with the AAAS. The program of the *American Psychiatric Association* (Harold E. Himwich, program chairman), will be a four-session symposium, "Physiological bases in psychiatry," 27 and 28 Dec.; the sessions—"New psychopharmacologic agents," "Mechanisms of actions in new agents," "Effects of alcohol on brain respiration and metabolism," and "Alcohol addiction"—will, in part, be a sequel to the highly successful program on psychiatry-pharmacology at the Berkeley meeting. This symposium at Atlanta will be cosponsored by Section N and the *American Physiological Society* (Fred A. Hitchcock, program chairman), which is tentatively planning a special program on the teaching of physiology.

Nd—Dentistry

Section Nd (Joseph F. Volker, program chairman) will have two symposia, "Newer knowledge of the physiology of the salivary glands" and "Oral structures in forensic medicine" on 28 Dec., cosponsored by the *American College of Dentists*, the *American Dental Association*, and the *International Association for Dental Research, North American Division.*

Np—Pharmacy

Section Np (John E. Christian, secretary) has scheduled seven sessions, 28–30 Dec., that will include a symposium and panel discussion on "Toxic household materials and appropriate antidotes," a specialized symposium on "Applications of nucleonics to the health professions," and contributed papers. The entire program will be cosponsored by the *American Association of Colleges of Pharmacy, American College of Apothecaries, American Pharmaceutical Association, Scientific Section*, and the *American Society of Hospital Pharmacists.*

O—Agriculture

The section (J. Fielding Reed, program chairman) is cosponsoring the entire symposium on "Atomic energy and agriculture," Section C's symposium on "Effect of chemical agents on biological organisms," and section G's symposia on "The tobacco plant" and "The cotton plant."

P—Industrial Science

Section P (H. M. Conway, Jr., program chairman) will have a two-session program, cosponsored by Section K, on "Resource development through science," which will include a regional case history of resource development—the South; specific resource studies on agriculture and land, water, minerals, and education and human resources; and a panel discussion that (i) will identify scientific approaches to the economic and industrial development of geographic areas, and (ii) will relate these specific techniques to the specific needs of the South. Section P will have its customary luncheon at which Malcolm Bryan, president, Federal Reserve Bank of Atlanta, will preside, and the retiring vice-presidential address of George L. Parkhurst will be given, on 28 Dec.

Q—Education

Section Q (Dean A. Worcester, secretary) anticipates an unusually strong program at the Atlanta meeting, 26–30 Dec. In addition to three sessions for contributed papers, there will be a symposium, "Education of the gifted," and another session, jointly with the *International Council for Exceptional Children*; three joint sessions with the *American Educational Research Association*; a two-session symposium, "Visual efficiency" arranged by N. Franklin Stump; a business meeting and a vice-presidential address by Carter V. Good. In addition, the section, together with the NSTA, AERA, the AAAS Cooperative Committee, the NABT, and the *Central Association of Science and Mathematics Teachers*, will cosponsor the symposium, "Implications and applications of recent research in science education" arranged by George G. Mallinson for the *National Association for Research in Science Teaching* (Clarence M. Pruitt, secretary), which also will hold its annual meeting with the AAAS.

The *AAAS Cooperative Committee on the Teaching of Science and Mathematics* (John R. Mayor, program chairman) will cosponsor the AAAS program on "The Crisis in Science Education." The regular regional meeting of the *National Science Teachers Association* (Katherine Hertzka, program chairman) with the AAAS will consist of some eight sessions, three of them jointly with ANSS and NABT.

X—Science in General

The annual *Academy Conference* (Leland H. Taylor, program chairman), composed of delegates and other numbers of the 42 academies affiliated with the Association, will hold a day of sessions and will sponsor the Tenth Annual Junior Scientists Assembly—a carefully planned program especially for high-school students interested in science. A new feature will be an Academy Information Center during the meeting period. The *American Geophysical Union* (Werner A. Baum, program chairman) will have three afternoon sessions, 27–29 Dec., to complement the three morning sessions of the International Geophysical Year, of which the AGU is a cosponsor.

The annual national meeting of the *American Nature Study Society* (Malvina Trussell, program chairman) will consist of a symposium, "Southern agriculture from 1913–1956," and social mixer, 27 Dec.; the annual banquet and presidential program—"Early naturalist explorers of the southeastern states" (illustrated) by Malvina Trussell, 29 Dec.; three joint sessions with the NABT and NSTA and a joint field trip, 30 Dec., with the NABT.

The fourth *Conference on Scientific Editorial Prob-*

lems (Marian Fineman and A. E. Tyler, cochairmen) plans several groups of invited papers on problems in editing, technical writing, and scientific publication. The fifth *Conference on Scientific Manpower* (Thomas J. Mills, program chairman) plans two afternoon sessions, 27 and 28 Dec., which will be cosponsored by the *Engineering Manpower Commission*, the *Scientific Manpower Commission*, the *NRC*, and the *NSF*.

The *National Association of Science Writers* (Odom Fanning, program chairman) will have its annual symposium and a business meeting with the AAAS. The annual address and award of the William Procter prize of the *Scientific Research Society of America* is scheduled for the evening of 29 Dec., following the society's joint luncheon with the Society of the Sigma Xi and the annual convention of RESA earlier that day. The annual address of the *Society of the Sigma Xi* will be held the evening of 27 Dec.; the 56th annual convention on the morning of 29 Dec. preceding the joint luncheon with RESA. The 16th annual lecture of the *United Chapters of Phi Beta Kappa* is scheduled for the evening of 30 Dec.

RAYMOND L. TAYLOR
Associate Administrative Secretary, AAAS

Radiation Hazards and Politics

An open meeting on Nuclear Radiation Hazards and their Political Implications was held in Washington, D.C., on 28 Apr. under the sponsorship of the local chapter of the Federation of American Scientists. With M. Stanley Livingston, professor of physics at Massachusetts Institute of Technology, as moderator, the subject was discussed by Sen. Clinton Anderson, chairman of the Joint Committee on Atomic Energy; Rep. Chet Holifield, a member of the Joint Committee; Bentley Glass, geneticist and professor of biology at Johns Hopkins University; and John S. Toll, chairman of the physics department at the University of Maryland. There was a capacity audience, consisting primarily of visitors from all over the United States who were in town to attend the annual Washington meeting of the American Physical Society.

In his opening remarks, Livingston described the difficulties the planning committee had encountered in finding a physicist to speak on the program.

> Refusals [were made for] . . . various reasons. Some described the impossibility of speaking authoritatively on a topic in which so much information is still classified; others expressed a downright fear of involvement in a controversial issue which might cause them security clearance trouble. After many refusals the planning committee did obtain acceptances from two physicists who are employed in the Defense Department. However, these physicists later withdrew when the Defense Department imposed new restrictions on public statements by its employees (the so-called "Wilson Order"). We did finally find a few competent authorities who would have been willing to speak but had other, over-riding engagements. Finally, in desperation and in open rebellion against these pressures, Dr. Toll and I agreed to stick our necks out and appear on this program.
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> This experience illustrates one of the political dilemmas in which we find ourselves. . . . Those who know won't speak, and those who don't know cannot speak with authority.

Next, in a presentation of general information, Toll discussed the physical effects of radioactivity caused by atomic bomb explosions. He emphasized that it is not possible to arrive at clear conclusions, that "The problem of radiation hazards is complex, for it involves such diverse fields as physics, meteorology, and biology, and depends on many phenomena which are not yet understood." He described the wide variety of possible atomic weapons and then went on to say that the general public, even some inner councils of the Government, are often considering defenses for last year's weapon rather than tomorrow's. "Sound planning requires not only information about previous explosions but also sensible guesses as to future developments. . . ."

After referring to the many contradictory statements in the press, Glass devoted his talk to an appraisal of the present knowledge of the genetic consequences of radiation. He pointed out that there are certain matters about which geneticists are in full agreement and presented the following summary.

> (i) High-energy radiation produces mutations in all kinds of plants and animals and microbes; and no one doubts that it will do so in human beings as well. (ii) The frequency of mutations in any particular species and kind of cell is proportional to the dose of radiation. . . . (iii) The effects of successive exposures are cumulative. (iv) There is no recovery. . . . (v) Mutations are overwhelmingly deleterious. . . . (vi) Mutations occur spontaneously; and only a portion, probably only a small portion, of them are caused by natural high-energy radiation. . . .

In conclusion Glass said:

> These are two grave dangers in the present situation. One is our ignorance. In particular, if the present number of harmful genes per person and the over-all spontaneous mutation rate are much lower than we now estimate them to be, then the danger of the present levels of radiation is correspondingly multiplied. Our ignorance of the true rate at which mutation is induced by radiation may luckily tend to counterbalance this if it turns out that the radiation-induced rate in the immature female germ cells is much lower than in the male. . . . Above all, there is our ignorance as to how much increase in the mutation rate a human population can tolerate.
>
> The second peril is that eventually, as the number of test explosions increases and the long-lived isotopes accumulate, as the industrial atomic energy plants multiply and the disposal of atomic waste products becomes a more and more critical problem, the cumulative exposure to radiation may come to exceed by far the 0.2 r/yr which was in 1949 the average dose received by Oak Ridge and Hanford workers. The present "permissible" dose of 0.3 r/wk or 15 r/yr, if delivered to the entire population, [might] multiply the present mutation rate by at least 4.5 and maybe

as much as 150 times. Who, knowing the predominant harmfulness of mutation, can dismiss such a possibility lightly?

Rep. Holifield urged that the United Nations be strengthened and observed that "It is high time we stopped treating that world organization as an orphan. . . ." He stated that neither civil defense nor air interceptor devices would do much good in a mass enemy H-bomb attack and indicated that our greatest safety lies in fully informing the world's population of the horrors of nuclear warfare. He suggested that the President make a series of television and radio talks to arouse the public.

Both Rep. Holifield and Sen. Anderson, the last speaker, expressed concern over the needless secrecy restrictions. Sen. Anderson indicated that secrecy sometimes goes to remarkable extremes and cited a case in which he urged declassification of a scientific finding that had already been published in prominent journals of three other countries. He was "enthusiastically voted down" by a majority of the committee. In commenting further on the Government's slowness in making information available, he pointed out that it was 10 months before there was any official report on the first hydrogen bomb explosion. The story of the effects of fallout on Japanese fisherman, which could have had no possible security implications, was concealed until the news was released from other sources. "We need to talk more frankly to the American people," he said. "I don't think they are afraid to face the facts."

Science News

Physicians, dentists, and veterinarians on active duty as commissioned officers in the military services and the U.S. Public Health Service receive salaries of $100 per month more than nonmedical officers of equal grade. To resolve this inequity, H.R. 2442 has been introduced into the Congress by Rep. Olin E. Teague (D., Tex.). This bill proposes a **bonus of $100 per month** for officers who hold a doctor's degree (or its equivalent) in science, and who are performing duties in the fields of their special training.

Many scientific organizations have officially endorsed H.R. 2442, including the Entomological Society of America, which has adopted a resolution containing the following paragraphs:

> WHEREAS, This Society holds that personnel possessing the degree of Doctor of Science or Doctor of Philosophy in entomology, parasitology, or any other basic science related to medicine and acceptable to the Surgeon General should be granted the same recognition, incentive payments, and other considerations extended to physicians, surgeons, dentists, and veterinarians by the Armed Services Career Compensation Act, therefore
>
> BE IT RESOLVED that the Entomological Society of America, through its Governing Board, go on record as unreservedly favoring the policy set forth in this resolution and favoring the passage of House Resolution 2442. . . .

Nearly **1100 abstracts** have been received by the Atomic Energy Commission from U.S. scientists and engineers who desire to participate in the United Nations International Conference on Peaceful Uses of Atomic Energy at Geneva next August. In announcing that the first group of 189 abstracts of papers tentatively accepted has been forwarded to the United Nations, Willard F. Libby, acting chairman of the AEC, expressed gratification at the widespread interest in the meeting shown by the scientific community.

> This overwhelming response is heartening for two reasons. It demonstrates our desire to share with the world the results of our researches and applications of atomic energy for peaceful purposes. Also, it gives evidence of the substantial contributions the United State has to make to all sections of the comprehensive agenda adopted for the conference.

George L. Weil, technical director of this country's participation in the conference, explained that this was only the first group of abstracts of United States papers to be submitted to the U.N.'s secretary-general of the conference. Weil also pointed out that within the time allotted to the United States at the conference, only a relatively small number of all the papers eventually accepted can be presented in person by the authors. Other papers will be published in the conference proceedings.

The 189 abstracts propose papers in the broad fields of applications of atomic energy to medical research, agriculture, and industry; applications of radioisotopes in process and quality control; industrial uses of fission products; developments in instrumentation and remote controls necessary for handling radioactive materials; and natural occurrence of uranium in this country and extracting and refining uranium ores. A list of the titles of all papers submitted so far for the conference, including the abstracts from the United States is available at U.N. headquarters in New York.

"Portrait of a scientist, a tribute to Linus Pauling" is the title of an article by George Beadle that appeared in the April issue of *Engineering and Science*, monthly publication of California Institute of Technology. In one section Beadle, who is chairman of the institute's division of biology and president of the AAAS, discusses the excesses of the security system.

> . . . [Scientists] want no special privileges. The intellectual freedom of science is no different in principle from any other kind of intellectual freedom. It is a counterpart of freedom of speech, of freedom of the press and of freedom of religion. None of these freedoms should be a freedom divorced from responsibility. No sensible person would claim otherwise.

The article ends with:

> I want to close by saying I regard it a great privilege to know and to be associated with Linus Pauling. . . . I am proud to belong to the faculty of an institution with the foresight to see his greatness and the wisdom to give its development full freedom. I am proud that Caltech has a president who knows the

true meaning of academic freedom and who has the courage to speak and act accordingly. I contrast our good fortune with the lot of a certain few of our sister universities whose presidents belie by their acts the fine-sounding words of their public utterances. I am grateful for a Board of Trustees that has not succumbed to the disease of mistrust and suspicion that could so easily undermine their faith in the wisdom of academic freedom and the rightness of liberal decency.

Kenneth H. Schmidt, a Danbury, Conn., inventor who was chief engineer of the White House communications system under President Roosevelt, now runs a successful business manufacturing a **wiretap-proofing device.** Confining himself exclusively to government work in Washington and Ottawa, he claims that he has made more than 100 installations in the Pentagon alone.

On 20 June (for Asia time-zones) the sun will be totally obscured by the moon for observers along a narrow strip of the earth's surface beginning in the Indian Ocean and extending east across Ceylon, Bangkok, Thailand, part of the Philippines, and the Pacific Ocean north of the Solomon Islands. At one point along this strip—in the South China Sea—the maximum duration of totality will occur—7 min, 7.9 sec. There will not be a **total eclipse** of longer duration in this century. In fact, according to many astronomers, the duration of this eclipse has not been surpassed since A.D. 717. In 1973 an eclipse of nearly the same duration will take place, but astronomical calculations indicate that it will be slightly shorter than the one this year.

Observers from Arabia to New Zealand will see this solar eclipse as a partial one. During the day of 20 June on the eclipse path, it will be the night of 19–20 June in New York. The eclipse will not be visible from any location in the American continents.

The American Museum of Natural History has announced the establishment of the **Southwestern Research Station** on the eastern slope of the Chiricahua Mountains, near Portal, Cochise County, in southeastern Arizona. The property, which is at an elevation of 5400 ft, is within the limits of Coronado National Forest. The year-round station was established to provide research facilities for investigators and students in all branches of science who are conducting studies that can utilize the faunal, floral, and geologic features of the area. The museum's new unit is under the direction of Mont A. Cazier, chairman and curator of the department of insects and spiders. All inquiries, and requests for the descriptive booklet that is available, should be directed to Cazier at the American Museum of Natural History, Central Park West and 79 St., New York 24.

In a paper delivered at the recent meeting of the Association of American Physicians, Albert B. Sabin of the University of Cincinnati described encouraging progress in his work with 30 prisoner volunteers who received **live polio virus** last January. All 30 participants in the experiment, inmates of the Chillicothe, Ohio, federal reformatory, produced resistance to the disease in the form of antibodies. In addition, none of the volunteers became ill from the infection they developed; in fact, infection could be determined only by laboratory tests. The men received varying amounts of the virus culture in a teaspoonful of milk. It was found that 0.001 ml of the fluid was enough to produce an immunizing infection.

The work, aided by a grant from the National Foundation for Infantile Paralysis, is still in progress. After successful experiments in which the viruses were changed from highly virulent or paralyzing varieties to nonvirulent or harmless varieties, the strains were considered safe for testing on human beings.

The U.S. Department of Agriculture has reported that, as of 20 Apr., more than 13 million acres of land in seven southern Great Plains states had been damaged by **wind erosion** since last November. This is 3 million acres more than was reported on 1 Apr. These estimates are based on information compiled by the Soil Conservation Service. In addition, another 19 million acres of land is in condition to erode because it lacks adequate vegetative cover. Secretary Benson is studying the affected areas.

A suit filed on 14 Mar. in U.S. District Court for the District of Columbia on behalf of **Martin D. Kamen,** associate professor of chemistry at Washington University in St. Louis, charges that procedures by which American citizens are denied passports by the State Department for alleged communist activities or affiliations restrict liberty and freedom to travel without regard for the "due process of law" guaranteed by the Constitution. Kamen and his supporters hope that the case will answer the basic question of whether or not the due process clause covers the right to travel. The Fifth Amendment states: ". . . nor shall any person . . . be deprived of life, liberty, or property without due process of law. . . ." Suppose a scientist wishes to attend a foreign conference or lecture in a foreign university. Can he, at the pleasure of the Passport Division, be deprived of the right to practice his profession? Or may his passport be denied only through procedures that satisfy the due process requirement?

In 1952, a Special Federal Court apparently sustained the latter view in the only previous case of the sort, that of Anne Bauer, a journalist. The court held that before the State Department could revoke a passport it would have to inform the person affected of the reasons therefor, and grant that person a hearing. In September of 1952 Secretary Acheson issued new regulations providing for an appeal procedure in cases of passports denied or revoked because of charges involving communism. However, even today, no appeal mechanism has been set up for cases not related to the communist question.

Kamen, who is one of the coinventors of the radiocarbon tracer technique, joined the staff of the Radi-

ation Laboratory of the University of California in Berkeley in 1936. During the war the laboratory became a part of the Manhattan Project, and many scientists there began to do secret work, including Kamen, who became a group leader. In 1944 he was called in by the personnel office of the laboratory and told that he was being dismissed for "indiscretion." No other explanation was given.

Kamen's passport was revoked in 1947, and he has not been able to regain it, although he has received numerous professional invitations from several foreign countries—England, Australia, France, and Israel. When he first made application to the Passport Division in September 1952, he was refused on the grounds that he had associated with known Communists, had belonged to an organization now on the Attorney General's list, and had furnished classified information to Soviet officials. Kamen has exhausted all means for administrative reconsideration of his case provided under State Department regulations. However, the original decision not to grant him a passport still stands, although both the Army and the Atomic Energy Commission have informed the Passport Division that they do not object to Kamen's leaving the country.

The current suit is the first step in judicial review of the case. It charges that in denying Kamen a passport, "his personal liberty and freedom to travel, work, and consult with others has been restricted, and his opportunity to acquire and disseminate knowledge essential to his professional advancement and the advancement in the field in which he works has been restricted." The State Department's action is characterized as "arbitrary, capricious and unlawful" because sufficient evidence to support the allegations on which denial of the passport was based was never presented. Consequently, it is asserted, the department's action violates the due process clause of the Fifth Amendment. A mandatory injunction directing the State Department to issue a passport is requested.

In April the Government filed a motion to dismiss, which was denied, that was based chiefly on the premise contained in this sentence from the brief: "Since earliest times the Secretary of State has had complete and absolute control and discretion over the grant or denial of passports."

A news release from the **Scientific Manpower Commission** reports that a survey it has just completed "indicates that industry is adding 5000 to 7000 new scientists a year to its payroll. More than 1000 companies took part in the study. Aided by a panel of 30 industrialists, educators, and Government scientists headed by E. B. Peck of Esso Research and Engineering Co., the commission canvassed 1600 employers to determine how many scientists they are hiring and losing. Howard A. Meyerhoff, executive director of SMC, estimates that the 58,670 scientists on company payrolls on 31 Dec. 1953 represent more than half of those employed in industry.

"Chemists outnumber all others combined, with 35,616 of the total. Geologists, physicists, biologists, mathematicians, and psychologists follow in that order. Women account for 7.6 percent of the total. The survey also revealed that slightly less than half of the scientists included in the tabulation work for large organizations employing 500 or more individuals with technical scientific training. . . . The report shows a labor turnover of 9.5 percent among the highly trained specialists, with roughly a 3-percent replacement rate for deaths, retirements, and losses to nontechnical occupations. In 1953, the year for which complete returns were obtained, 8.2 percent of the losses were to the armed forces.

"Noting a drop of nearly 500 in the number of scientists hired in 1953 as compared with 1952, the report points to the 12-percent drop in the number of science graduates in the same 1-year period. Although he would not say definitely that the two were related, Meyerhoff stated:

> Industry failed to get all the scientists it needed in 1953 and again in 1954, when there was a further decline of 4 to 5 percent in the number of scientists graduating with bachelors' degrees. The dwindling numbers must have been a factor, but other factors cannot be ignored—for example, the heavy drain for military service, especially after Korea, when many deferments were terminated.

H. Van Pel, the fisheries officer for the South Pacific Commission, has announced that Dutch scientists have caught large **sharks and sawfish in a mountain lake** called Sentani 20 mi inland in western Dutch New Guinea. Some of the smaller species have been sent to the Netherlands for examination. The scientists were unable to name the variety of sharks, but one sawfish was reported to be more than 10 ft long.

How these salt-water fish became acclimated to fresh water in a lake 500 ft above sea level is unknown. The only explanation that has been suggested, Van Pel said, is that

> . . . the lake, thousands of years ago, was fed from the sea at sea level. Then a volcano eruption took the lake 500 ft up when mountains rose out of the sea. The change from salt to fresh water was so gradual that the sharks and other fish became acclimated to it.

The first direct **synthesis of testosterone** from simple coal-tar products has been accomplished by a group of chemists at the University of Wisconsin. The research that led to the synthesis was carried out by W. S. Johnson and a colleague, Raphael Pappo, visiting lecturer in chemistry from the Weizmann Institute, Israel, in cooperation with Brian Bannister and E. J. Pike. The project is part of a broad research program at Wisconsin for the synthesis of hormones involved in sex, pregnancy, and the life-maintenance substances produced by the adrenal glands.

The only practical method to date for synthesizing testosterone has required that a complex natural steroid such as cholesterol be used as a starting point. Johnson and Pappo synthesized the sex hormone from the coal-tar product 1,6-dimenthoxynaphthalene. However, they have emphasized that the method is not practical in its present form.

Scientists in the News

Leonard Woolley, British archeologist, has received the Lucy Wharton Drexel medal, highest award of the University Museum of the University of Pennsylvania. The medal was presented on 21 Apr. when he opened a rebuilt University Museum exhibit hall, "The Royal Tombs of Ur," which provides a new setting for some of the 4500-year-old jewelry, art objects, and human remains discovered by the Woolley expeditions in Iraq. The new hall was designed by Antonio Lebrija, an artist-anthropologist of Mexico's National Institute of Anthropology and History. The Drexel medal is given for the "best archaeological excavation, or for the best publication based on archaeological research by an English-speaking scholar within the previous five years." It has been awarded only once since 1913 and only 12 times since it was established in 1902.

Woolley, who celebrated his 75th birthday last month, has dug for almost half a century in Nubia, Egypt, Syria, Iraq, and Turkey. He is being cited especially for four of his recent publications. They are *Alalakh* (1953), the story of his unearthing of an ancient city in southern Turkey before and after World War II; *Spadework* (1953), a popular summary of his field experiences since 1906; *Carchemish III* (1954), a scientific report of his excavations in Syria more than 40 years ago; and *Early Periods,* which is now being published and is the fifth volume of his series on Ur.

R. S. Jane and H. G. Thode have been appointed new members of the **National Research Council of Canada** for 3-year terms that began 1 Apr. Jane is executive vice president of Shawinigan Chemicals Ltd., Montreal, and Thode is principal of Hamilton College and director of research at McMaster University, Hamilton, Ont.

Retiring members are Brig. F. C. Wallace, executive vice president, Duplate Canada Ltd., Fiberglas Canada Ltd., and Smith and Stone Ltd., Toronto, Ont.; and J. H. L. Johnstone, head of the department of physics and dean of the faculty of graduate studies, Dalhousie University, Halifax, N.S. Both have given their services to the council continuously for 6 years.

Three other members have been reappointed for a further term of 3 years. They are C. J. Mackenzie, president, Atomic Energy Control Board, Ottawa, Ont.; T. Thorvaldson, dean of graduate studies emeritus, University of Saskatchewan, Saskatoon; and W. H. Watson, professor and head of the department of physics, University of Toronto, Toronto.

Murray Gell-Mann, former assistant professor of physics and member of the Institute for Nuclear Studies at the University of Chicago, has joined the staff of California Institute of Technology as associate professor of physics. Gell-Mann's work has been concerned with the theory of atomic nuclei and the basic particles of which nuclei are composed.

E. Kennerly Marshall, Jr., professor of pharmacology and experimental therapeutics in Johns Hopkins University School of Medicine, will retire from active service at the end of June. He will be succeeded as professor and head of the department by **Gilbert H. Mudge,** now associate professor of medicine at Columbia University College of Physicians and Surgeons. With the exception of 2 years, 1919–1921, at Washington University, St. Louis, Marshall has been a member of the Hopkins medical faculty continuously since 1911 and has served under six of the seven presidents of the university. In his long and outstanding career, Marshall has taught and conducted his researches in three different fields of medical science, physiological chemistry, physiology, and pharmacology, the latter two as professor and head of department.

Herbert B. Nichols, formerly science editor of the *Christian Science Monitor* and information officer, U.S. Geological Survey from 1949 to 1954, has returned to the latter post after a year with General Electric Co. at Schenectady, N.Y., where he aided in the establishment of a public relations unit for the Research Laboratory. **Ned Landon,** who joined the staff at the laboratory as an information specialist in 1954, has been named manager of public information.

Laurence Irving, chief of the physiology section, Arctic Health Research Center, Anchorage, Alaska, was recently made a member of the Norwegian Academy of Science and Letters.

Gregory Zilboorg, practicing psychiatrist, consultant in criminology to the United Nations, and clinical professor of psychiatry at the State University of New York College of Medicine in Brooklyn, has been elected vice president of the International Congress of Criminology that is to take place in London, 11–18 Sept.

James Henry Ferguson, assistant professor in Tulane University School of Medicine, has been appointed professor of obstetrics and gynecology and chairman of the department at the School of Medicine, University of Miami, effective 1 June.

Bernard C. Glueck, Jr., of Ossining, N.Y., director of scientific research (sex aberrations) at the New York Psychiatric Institute and since 1952 director of the sex delinquency research project at Sing Sing Prison, will leave state service on 31 July. Glueck, who is also attending psychiatrist at Ossining General Hospital, instructor in psychiatry at Columbia University, and associate psychoanalyst at Columbia University Psychoanalytic Clinic, will sever his present affiliations to become an associate professor in the department of psychiatry at the University of Minnesota Medical School. The results of Glueck's 6-year research project in sex delinquency for the state of New York will be released sometime later this year.

Sponsored by a central committee of the Swedish Medical Schools, **Mark Nickerson,** professor of pharmacology and medical research at the University of Manitoba, Winnipeg, Canada, recently presented a series of lectures on various aspects of shock and of autonomic nervous system blockade at Stockholm, Lund, Göteborg, and Uppsala, Sweden. He also lectured in Denmark, England, and Scotland during his trip.

Robert B. Woodward, Robert Loeb professor of chemistry, has been selected as Harvard University's leading contributor to science and the benefit of mankind in 1954–55. President Nathan M. Pusey recently presented him with the newly established George Ledlie prize, a $1000 award that is recommended by vote of the council of deans. It is to be given every 2 years.

Woodward, who synthesized quinine 10 years ago and who made important contributions to the synthesis of cortisone, reported two more major chemical results last fall: the synthesis of strychnine, an achievement in pure research; and the synthesis of lysergic acid, which is widely used in obstetrical medicine.

Ernest W. Goodpasture, professor of pathology at Vanderbilt University, and originator of the method of growing viruses in a fertile egg culture, was recently awarded the Howard Taylor Ricketts medal of the University of Chicago. The award is a national honor given by the university in recognition of outstanding work in medical research.

Alfred P. Kraus, assistant director of the department of medical laboratories of the University of Tennessee College of Medicine, and his wife, **Lorraine M. Kraus,** who is a graduate student in the university's division of chemistry, will assist the University of Indonesia, Djakarta, in the reorganization of its medical college. Kraus, who will depart 1 July on a year's leave of absence, will become visiting assistant professor of hematology, and Mrs. Kraus will follow in September to serve as an instructor in biochemistry. The couple will be participating in the University of California-University of Indonesia project in medical education that is sponsored by the State Department.

Henry Wise, senior physicist, has joined the physical sciences division of Stanford Research Institute. He was formerly a group leader in chemical kinetics and combustion in the Jet Propulsion Laboratory of California Institute of Technology. At S.R.I. Wise will aid in the establishment of a group in chemical physics to conduct fundamental research on problems related to combustion processes.

Walsh McDermott, editor of *American Review of Tuberculosis and Pulmonary Diseases,* will succeed **Esmond R. Long** as director of medical research of the National Tuberculosis Association when the latter retires on 1 July. In addition, **Floyd M. Feldmann,** formerly assistant to N.T.A.'s managing director, has been named medical director and will be associated with McDermott in the conduct of the research program.

Long, who is also director of the Henry Phipps Institute of the University of Pennsylvania, Philadelphia, is relinquishing all administrative work to devote his time to research and writing. He has headed the N.T.A. division of medical research since an expanded research program was launched in 1947 and has directed the program through its years of greatest growth.

James S. Robertson heads the newly formed medical physics division, formerly a part of the physiology division, at the Brookhaven National Laboratory, Upton, N.Y. Other members of the group are V. P. Bond, E. E. Stickley, and Richard I. Weller. The new division studies problems of radiation dosimetry, both biological and physical.

An **international team of scientists** is joining the staff of the United Nations in New York to assist in preparations for the International Conference on the Peaceful Uses of Atomic Energy that will be held in Geneva next August. These men will serve as scientific secretaries under the conference secretary-general, Walter G. Whitman, and his deputy, Viktor Vavilov. Fourteen of them have started on their duties, and the other three are expected soon. The group contains three men from the United Kingdom, two each from Canada, France, the Union of Soviet Socialist Republics, and the United States, and one each from Argentina, Brazil, India, Japan, the Netherlands, and Yugoslavia. A list of the scientific secretaries follows:

Robert A. Charpie, assistant director of research, Oak Ridge National Laboratory, Oak Ridge, Tenn.; physicist, age 29.

Frederic de Hoffmann, assistant vice president for nuclear planning, Convair Division of General Dynamics Corp., San Diego, Calif.; physicist, age 30.

Donald J. Dewar, scientific adviser to the Atomic Energy Control Board of Canada, Ottawa; chemist, age 39.

Nikolai A. Dobrotin, deputy director and chief of the Laboratory on Cosmic Rays of the Lebedev Physical Institute of the Academy of Sciences of the U.S.S.R., Moscow; professor, physicist, age 46.

André Finkelstein, Ingénieur au Commissariat à l'Energie Atomique, Paris; chemist, age 32.

John Gaunt, principal scientific officer, United Kingdom Atomic Energy Authority, Harwell, Berkshire; chemist, age 35.

Jacob A. Goedkoop, senior scientist, Norwegian-Netherlands Joint Establishment for Nuclear Energy Research, Kjeller, Norway; physical chemist, age 33.

Reinosuke Hara, research fellow at Harvard Medical School and secretary of the Japan Radioisotope Association; chemist, age 30.

Elwyn O. Hughes, research officer, Division of Applied Biology, National Research Council of Canada, Ottawa; biologist, age 39.

Leonard F. Lamerton, senior assistant physicist, Royal Marsden Hospital, London; reader in physics applied to medicine, University of London; biophysicist, age 39.

José Leite Lopes, member, Atomic Energy Commission of the Brazilian National Research Council; professor, physicist, age 36.

Derrik J. Littler, principal scientific officer, United Kingdom Atomic Energy Authority, Harwell, Berkshire; physicist, age 35.

Aleksander Milojevic, Institute "Boris Kidric," Vinca, Belgrade, Yugoslavia, physicist.

Brahm Prakash, Atomic Energy Commission of India; metallurgist.

Ivan D. Rozhansky, scientific secretary of the physical section of the Physics and Mathematics Department, Academy of Sciences of the U.S.S.R., Moscow; physicist, age 41.

César A. Sastre, staff member of the reactor group, Comisión Nacional de la Energia Atómica, Argentina; engineer, age 27.

Michel Trocheris, Commissariat à l'Energie Atomique, Centre de l'energie nucléaire de Saclay, France; physicist, age 34.

Maj. Gen. J. D. O'Connell has been sworn in as Chief Signal Officer of the U.S. Army; he had been the Deputy Chief Signal Officer for the past 3½ years.

James W. and Constance S. Warwick, both of Harvard University, have been appointed to the scientific staff of the University of Colorado's High Altitude Observatory. They will carry out research on the formation of solar flares and their relationship to the solar corona, and will also study effects of solar activity on the earth, with particular emphasis on ionospheric effects.

The Franklin Institute and the Rittenhouse Astronomical Society held a joint meeting at the institute on 22 Apr. during which the society presented its Rittenhouse medal to **Harold Spencer Jones,** head of the Greenwich Observatory since 1933 and British Astronomer Royal. Jones spoke on "Life on other worlds," the title of a book that he wrote 25 years ago.

The Johnson Plaquette, an international award established by the Royal Swedish Academy of Engineering Sciences, was presented for the first time to **Pierre Ailleret,** the Research Director of Electricity of France. Ailleret was recognized for contributions to the development of the French electric power system.

The Johnson Plaquette is supported by a gift from the first honorary member of the Swedish academy, the shipowner and industrialist Axel A. Johnson. Every second or third year, a technologist is to be invited to deliver an honorary public lecture describing his research contribution to the engineering sciences. In conjunction with the lecture, the plaquette will be presented to the lecturer, and in addition he will be invited to make a study tour of Sweden, accompanied if he wishes by a member of his family.

Robert L. Fullman has been appointed manager of the new materials and processes studies section at the General Electric Research Laboratory in Schenectady. He has been at the Research Laboratory since 1948, specializing in studies of recrystallization, grain growth, and the origin of microstructures in metals and alloys.

Maurice S. Tarshis, former director of the tuberculosis research laboratory, Veterans Administration Medical Teaching Group Hospital, Memphis, Tenn., and director of tuberculosis bacteriology research at the Veterans Administration Hospital, Oteen, N.C., has been appointed to the research staff of the department of bacteriology, University of California, Berkeley.

Helgi Johnson, director of the Bureau of Mineral Research and chairman of the department of geology at Rutgers University, has been named executive director of the Yellowstone-Bighorn Research Association at Red Lodge, Mont., effective 1 June.

Meetings

The 1955 **Heat Transfer and Fluid Mechanics Institute** that will take place at the University of California, Los Angeles, 23–25 June, is the eighth of a series initiated in 1948 for the purpose of making avaliable to engineers of the western region a program of high scientific caliber representing fundamental contributions to the engineering sciences. Participation in the institute has been on a nationwide basis, with representation both in audience and speakers from industrial centers and universities throughout the nation. Preprints of all papers are included in a bound volume that will be available at the meeting.

Sponsored by the University of Minas Gerais, a **Symposium on Cytology and Cytochemistry of Secretion** was held in Belo Horizonte, Minas Gerais, Brazil, 14–18 Mar. Visiting participants came from the University of São Paulo and from the University of Brazil, Rio de Janeiro.

There were reports and discussions on: general aspects of cell secretion, biochemistry of cell secretion; role of mitochondria and Golgi apparatus in cell secretion; behavior of the nucleolus in secretory cells; intranucleolar modifications during regeneration of the liver; cytochemistry of the salivary chromosomes of *Rhyncosciara angelae*. The papers presented will be published in English by the University of Minas Gerais under the editorship of G. Schreiber of the university's Institute of Biology.

Fisk University is sponsoring its 6th annual **Infrared Spectroscopy Institute,** 29 Aug.–2 Sept. Morning sessions will be devoted to introductory lectures, afternoons to laboratory work, and evenings to lectures on more advanced topics of a specialized nature. Laboratory facilities will include a variety of single- and double-beam spectrometers of both uni-

versity and commercial design that will permit the covering of a spectral range from the visible to the far infrared.

In addition to introducing the participants to the methods and scope of infrared spectroscopy, the institute will provide an opportunity for advanced workers to enter into discussions with faculty members concerning problems of their own particular interest. This year the guest faculty is composed of Robert C. Gore of the American Cyanamid Co.; Alvin Nielsen of the University of Tennessee; and A. Lee Smith of the Dow-Corning Co. Regular faculty members include Nelson Fuson of Fisk University; Ernest Jones of Vanderbilt University; and James Lawson of Tennessee A. and I. State University. Further information may be obtained by writing to Nelson Fuson, Infrared Spectroscopy Institute, Fisk University, Nashville, Tenn.

A 3-day international symposium on **Enzymes: Units of Biological Structure and Function,** sponsored by the Henry Ford Hospital, Detroit, Mich., and the Edsel B. Ford Institute for Medical Research, will be held in the auditorium of the hospital, 1–3 Nov. Interrelationships between enzymology and other fields, notably genetics, physiology, biochemistry, and pharmacology, will constitute the general theme of the symposium. The specific topics for the six sessions will be as follows: origin of enzymes; status of the gene-enzyme relationship; enzymes and cell structure; enzymatic basis of some physiological functions; cellular energy sources; and regulation of enzyme activity. More than 30 internationally known scientists have agreed to participate.

Interested persons may secure a copy of the preliminary announcement by writing to Dr. Clarence E. Rupe, Henry Ford Hospital, Detroit 2, Mich. Invitations will be sent to as many as can be accommodated.

Seven symposiums will highlight the 32 technical sessions scheduled for the 58th annual meeting of the **American Society for Testing Materials** to be held at Chalfonte-Haddon Hall, Atlantic City, N.J., 27 June to 1 July. The symposiums, some of them continuing through 3 sessions, will deal with impact testing, judgment of factors in soil testing, high purity water corrosion, atmospheric corrosion of nonferrous metals, speed of testing, and metallic materials for service above 1600°F. Many sessions of individual papers will cover soils, nonferrous metals, steel, tests of concrete, fatigue, and effect of temperature. There will be a panel discussion on pyrometric practice in elevated temperature testing sponsored by the Joint A.S.T.M.-A.S.M.E. Committee on Effect of Temperature on the Properties of Metals. In addition, about 50 of the society's chief technical committees and their subgroups have scheduled about 600 meetings in the 5-day period.

The annual Marburg lecture, established by the society to honor its first secretary, will be presented by Walter J. Hamburger, director, Fabric Research Laboratories, Inc., Boston, Mass., who will speak on "A technology for the analysis, design, and use of textile structures as engineering materials." The Gillett Memorial lecture, sponsored jointly by A.S.T.M. and the Battelle Memorial Institute to honor Horace W. Gillett, the first director of Battelle, will be presented by Fritz V. Lenel of Rensselaer Polytechnic Institute. He will discuss "Powder metallurgy—now." The address by retiring president Norman L. Mochel will review problems relating to the identification of materials.

Society Elections

New Orleans Academy of Sciences: pres., Willis Eggler, Sophie Newcomb College; v. pres., Leon Segal, Southern Regional Laboratory; sec., John H. Mullahy, Loyola University; treas., Hyacinth Blanchard, Metairie High School.

Brooklyn Institute of Arts and Sciences: pres., Robert E. Blum; sec., Lloyd R. McDonald; treas., Paul F. Ely. The vice presidents are Francis T. Christy, Charles Pratt, and Donald G. C. Sinclair.

New York Academy of Dentistry: pres., Willard T. Keane, New York; pres.-elect, C. Raymond Wells, Brooklyn; v. pres., W. Ward Tracy, New York; treas., Gustav P. Frahm, Flushing; sec., Norman L. Hiliyer, Hempstead.

Iowa Academy of Science: pres., U. A. Hauber, St. Ambrose College; v. pres., Walter F. Loehwing, State University of Iowa; sec.-treas. and representative to AAAS Council, Jean L. Laffoon, Iowa State College; editor, David G. Mobberley, Simpson College.

Ohio Academy of Science: pres., Paul Rothemund, Yellow Springs; sec., Ralph W. Dexter, Kent State University; treas., Elton Paddock, Ohio State University.

American Society of Biological Chemists: pres., J. Murray Luck, Stanford University; pres.-elect, Herbert E. Carter, University of Illinois; sec., Philip Handler, Duke University; treas., Philip P. Cohen, University of Wisconsin.

Electron Microscope Society of America: pres., T. F. Anderson, University of Pennsylvania; pres.-elect, W. L. Grube, General Motors Research Department; past pres., R. G. Picard, Radio Corporation of America, Camden, N.J.; sec., Miss J. R. Cooper, General Electric Co., Nela Park, Cleveland 12, Ohio; treas., Max Swerdlow, National Bureau of Standards, Washington 25, D.C.

The **Kresge-Hooker Science Library Associates:** pres., Stanley S. Kresge, Kresge Foundation, Detroit, Mich.; v. pres., Harvey M. Merker, Parke-Davis and Co., Detroit, Mich.; sec.-treas., Icie Macy Hoobler, Merrill-Palmer School, Detroit, Mich.; acting exec. sec., Wendell H. Powers, Wayne University. The representative to AAAS Council is Byron Soule, University of Michigan.

Education

The **Smithsonian Institution** and **Harvard University** have announced that they will associate their activities in astrophysical research to strengthen and enlarge the programs of both institutions. Fred L. Whipple of Harvard will become director of the Smithsonian's Astrophysical Observatory, effective 1 July. He succeeds L. B. Aldrich, who is retiring. At the same time, headquarters of the Smithsonian's Astrophysical Observatory will be moved to Cambridge, Mass., in order that astronomers may work in close association with Harvard's program of solar research. Some administrative and mechanical work will continue in the laboratories and shops of the Astrophysical Observatory at the Smithsonian Institution in Washington, and the two observatories of the Smithsonian Institution in Chile and at Table Mountain, Calif., will be maintained.

Whipple will continue to be professor of astronomy at Harvard, and it is contemplated that there will be other joint appointments by the two institutions. As a professor, Whipple will remain a member of the Harvard College Observatory Council, the policy-making group for research and teaching in astronomy at the university. As director of the Smithsonian's Astrophysical Observatory, he will become a member of the Solar Associates group, a coordinating body of scientists representing Harvard, the High Altitude Observatory at Climax, Colo., the Upper Air Research Observatory of the Air Force at Sunspot, N.M., and the Central Radio Propagation Laboratory of the National Bureau of Standards at Boulder, Colo.

The new **Richard B. Wetherill Chemistry Laboratory** at Purdue University will be dedicated 16–17 June. The $4-million building contains 3 million cubic feet and provides 160,000 ft^2 of usable floor space. The new unit is designed to contain all activities of the department except the teaching of freshman chemistry. Among those who will participate in the dedication program are Willard Libby, commissioner, U.S. Atomic Energy Commission; John C. Warner, president-elect, American Chemical Society; Max Tishler, vice president, Merck and Co.; and Linus Pauling, head, department of chemistry, California Institute of Technology.

How important scientific advances have affected national affairs and international relations is the subject of a course to be introduced in the College of Arts and Science, University of Rochester, next September.

Entitled **"Science in National and International Affairs,"** the course is aimed at nonscience majors who have had some science courses and who may—in the course of their future careers in government, business, and industry—have to make decisions that involve fundamental knowledge of scientific developments and problems related to them.

The course will be taught by W. Albert Noyes, professor of chemistry and former chairman of the department, and dean of the graduate school. The effect of scientific advances on national and international affairs will be illustrated by selected examples. The scientific activities of the United States government and their relation to the national economy and the national defense will be discussed, and the scientific activities of the United Nations and its specialized agencies and their relation to the foreign policy of the United States will be considered.

Miscellaneous

Among the articles in the June issue of **The Scientific Monthly** is "Cultivating our science talent—key to long-term security" by Donald A. Quarles. Quarles' article is based on an address given at the awards banquet of the Fourteenth Annual Science Talent Search, in Washington, 28 Feb. The other articles included in this issue are "New science of radio astronomy," Bart J. Bok; "What is ecology?" Lee R. Dice; "An insect Pompeii," Reginald D. Manwell; "Spontaneous activity and behavior," Kenneth D. Roeder; and "Medicinal uses of plants by native Inaguans," William H. Sawyer, Jr. There are 30 book reviews in this issue and letters from Arthur L. Mottet, Charles E. Whitmore, Addison Gulick, H. C. Lansdell, H. Richard Rasmusson, Lou Bahm, and Richard H. Lampkin.

William M. Mann, director of the National Zoological Park in Washington, D.C., has presented his collection of more than **117,000 specimens of ants** to the Smithsonian Institution. This gift makes the Smithsonian's ant collection one of the most complete in the world, raising the number of type specimens it contains from 1200 to 1900. There are approximately 8000 kinds of ants in the world, but type specimens are widely scattered. (A type specimen is a specimen on which the original scientific description of a species is based.)

In order to provide more adequate space for its news service and regional editorial staff, the **American Chemical Society's New York office** has moved to 2 Park Ave., New York 16.

The following **chemicals** are wanted by the Registry of Rare Chemicals, Armour Research Foundation of Illinois Institute of Technology, 35 W. 33 St., Chicago 16, Ill.: 2-chloro-3-nitroaniline; 2,3,5-tribromoaniline; 2,3,6-tribromoaniline; 2,3-dibromoaniline; 2-bromo-3-nitroaniline; 2,5-dibromoaniline; 2-methyl-1,3-dioxolane; 2-benzoyl-1,3-diphenyl-1,3-propanedione; *tert*-butyl chomate; tris-hydroxymethyl melamine; glyceric acid-2,3-diphosphate; tetrahydro-2-methyl-6-(3-pyridyl)-2H-1,2-oxazine; 3,5-dinitrophenylisocyanate; 4-biphenyl isocyanate; 1-naphthyl isothiocyanate; 2,4,6-trimethylphenol (Mesitol); 1,2-diaminocyclohexane; chloroiodomethane; phenanthro (1,10,9,8,fghij) perylene (meso-naphthodianthrene); and cyclohexanecarboxaldehyde.

Book Reviews

Progress in Biophysics and Biophysical Chemistry. vol. 4. J. A. V. Butler and J. T. Randall, Eds. Academic Press, New York; Pergamon Press, London, 1954. viii + 339 pp. Illus. + plates. $9.50.

This volume will be a welcome addition to the libraries of many workers in the biological sciences. I was greatly impressed by the catholic selection of topics, not only in this volume but also in the preceding ones. The editors, in not limiting themselves to topics that require an advanced knowledge of physics or physical chemistry, have been able to satisfy the needs of a large group of biologists. For example, in the chapter on chromosome breakage, the emphasis is on the biological aspects rather than on the use of x-irradiation as a tool. This approach was used particularly by J. C. Kendrew in his review of the elucidation of the structure of crystalline proteins. He has attempted, with a certain amount of success, to avoid the use of the jargon common to the crystallographer in explaining the techniques and results of x-ray diffraction studies.

Throughout this volume, the authors have presented critical reviews, occasionally taking part in the current controversies, but more often presenting many views without committing themselves to a particular theory. The latter approach, unusual in the field of muscle physiology and chemistry, is evident in the two chapters on muscle physiology, one by Weber and Portzehl, and the other by Wilkie.

The remaining articles include a review of the advances made in the study of nucleoprotein of the cell nucleus by Davison, Conway, and Butler; a discussion of polyelectrolyte gels by Katchalsky; and a chapter on the elucidation of the structure of nerve fibers by Fernandez-Moran.

I look forward to the continuation of this fine series.

HOWARD B. BENSUSAN

Department of Physiology,
University of Maryland School of Medicine

Chemistry of Lichen Substances. Yasuhiko Asahina and Shoji Shibata. Japan Society for the Promotion of Science, Tokyo, 1954 (Order from Maruzen, Nihonbashi, Tokyo). v + 240 pp. Illus. $2.50.

This is an English translation, *in toto*, of the authors' book that was published in Japanese in 1949. It has been made to conform to the date of publication only by the inclusion of some references that appeared as recently as 1953. The translation permitted the correction of errors that were in the Japanese edition.

The book is divided into three parts. Part I includes a very brief historical account of the study of lichen substances; a classification of these substances into 10 groups on the basis of chemical structure; a short chapter on their extraction, isolation, and purification; and a description of microchemical methods, including paper chromatography, for the detection and separation of lichen substances. Part II is devoted to a description of the occurrence and properties, including methods of isolation, of the lichen substances, and also to a discussion of their structure; this accounts for 185 of the 240 pages. Part III contains a discussion of biogenetic relationships and an account of the antibiotic properties of lichen substances. Each chapter includes a list of references that adds value to the work.

The authors have brought together the data found in the literature and have supplemented it with their own experience and knowledge. This book is a ready and authentic reference and should be of value to those who are especially interested in the plant sciences, particularly in plant chemistry.

LOYD E. HARRIS

College of Pharmacy, Ohio State University

Introduction to Theoretical Mechanics. Robert A. Becker. *International Series in Pure and Applied Physics.* Leonard I. Schiff, Ed. McGraw-Hill, New York–London, 1954. xiii + 420 pp. Illus. $8.

This book, designed to meet the needs of undergraduate juniors and seniors majoring in engineering physics at the University of Illinois, clearly reflects an engineering emphasis and consequently does not have the structure usually associated with the term *theoretical mechanics* as it is used by a physicist. In his preface, the author states that the topics are arranged in "order of increasing difficulty as to both mathematical maturity and physical insight required," and there is a heavy emphasis on the solution of problems. The 400-odd problems in the book, as well as the text itself, display a rather amazing range of difficulty and intellectual challenge. Thus, for example, at the end of the first chapter one finds problems that could be expected in high-school courses in physics, whereas toward the end of the book the problems take on the stature of graduate courses.

After a first chapter devoted largely to the elements of vector analysis, which is used consistently throughout the text, and an elementary statement of Newton's laws of motion, the statics of a particle, statics of rigid bodies, and statics of the suspended string or cable are developed in considerable detail. Then a chapter on work and the stability of equilibrium and an elementary chapter on the motion of a particle in a uniform field follow. The text then develops into what one usually expects to find in a textbook on theoretical mechanics.

There are several curious consequences as a result of the order in which the author has developed the material. For example, the first mention of kinetic

energy appears in a chapter concerned with statics, as do the concepts of work and potential energy. The discussion of the motion of a particle in a central field occurs very late (Chap. 10 of a 15-chapter book), so that the intimate relationship of the concepts of torque and angular momentum to this material is somewhat hidden.

A few minor points might be mentioned, such as the labeling of the first chapter as "Fundamental principles." In the discussion of the motion of a rigid body in a plane, it is gratifying to find the proper warning concerning the indiscriminate application of the torque-angular momentum relationship about an instantaneous axis, a point unfortunately omitted in most elementary and intermediate treatments of the subject. However, at this point it is curious to read about "accelerations acting on P," where P refers to a point through which the instantaneous axis passes. An amplification of this particular section would be welcome, as would a similar amplification of the very brief treatment of motions involving variable mass and of nonlinear oscillations.

On the whole, this book appears, to a physicist, to be a mixture of theoretical applied mechanics and theoretical physics. Perhaps this is necessary for the proper education of a major in engineering physics, but it limits the value of the book as a textbook for students majoring in pure physics.

N. H. FRANK

Physics Department,
Massachusetts Institute of Technology

The Application of Results of Research. Vera Connell, Ed. In collaboration with the British Commonwealth Scientific Offices. Academic Press, New York; Butterworths, London, 1954. vii + 212 pp. $5.

This book is the result of a report presented to the British Commonwealth Scientific Conference that was held in Australia in 1952. It deals with the basic problem of how to translate the results of scientific research into practice.

For most readers, the meat of the work is probably in the five short chapters, which occupy only one-fifth of the book. These chapters give brief evaluations of the various methods that are used to obtain the rapid dissemination and application of research findings, and some attention is given to the obstacles to the use of scientific information. Unfortunately, some topics are treated in such a sketchy fashion that no new ideas are communicated.

For other readers, however, the real meat may well be the nine appendixes that make up the balance of the book. Eight of these are reports on research activities and practical applications in the various Commonwealth areas. There are, for example, brief summaries of the activities of the Rubber Research Institute and the Tea Research Institute in Ceylon, of the Fisheries Research Board in Canada, and of the Council for Scientific and Industrial Research in South Africa. The final appendix, incidentally, is entitled "Some novel methods employed in the U.S.A." Here the methods of research organization and implementation that are used by three of our agencies are summarized, with the Tennessee Valley Authority in the stellar role.

Although this book is somewhat brief and its scope is limited—in that it concentrates on government-sponsored research and its application in a few fields, namely, industry, agriculture, and health—it is a welcome addition to the literature that concerns itself with the uses of scientific knowledge.

GUY B. JOHNSON

Department of Sociology and Anthropology,
University of North Carolina

Psychological Testing. Anne Anastasi. Macmillan, New York, 1954. xiii + 682 pp. Illus. $6.75.

In the 50 years since Binet and Simon produced the first practical psychological test, the development and use of new tests has increased at a phenomenal pace. Theory and practice have proceeded, occasionally apace, more often alternatively, but both have made great strides. In such a rapidly developing field, it is difficult for the practitioner to retain his perspective and for the student to acquire understanding and skill in the use of tests. Anastasi has contributed a well-written work intended to meet the needs of the beginning student and the practicing psychologist, the business executive, the psychiatrist, and the educator. It will be particularly welcomed by those already familiar with testing and a stimulating and challenging, but rather difficult, introduction for students.

The material is presented in four major sections: "Principles of psychological testing," "General classification tests," "The differential testing of abilities," and "The measurement of personality characteristics." Especially welcome is the treatment of materials so far omitted from most introductory textbooks, materials such as Cronbach's formulation of the reliability problem and the materials on factor analysis. Anastasi's well-deserved reputation for sound scholarship should be enhanced, an especially noteworthy achievement in the light of the book's introductory nature.

In the preface, Anastasi sets her task as follows:

> The primary objectives . . . are to provide an introduction to the principles of psychological testing and to acquaint the reader with the major types of tests in current use.

In general, she has succeeded quite well. The first section on principles will serve as a vantage point from which the student can survey and evaluate the later descriptions of the many kinds of tests available.

There are two major difficulties that may make the book rather difficult as a text. In the first place, Anastasi has tried to write a book that assumes no previous training in statistics. She attempts throughout to weave in discussions of statistical concepts as

they occur in connection with tests or theoretical points. On the basis of my experience, I seriously doubt the feasibility or even the desirability of such an attempt.

Second, there are some organizational difficulties. As is indicated previously, the discussion of factor analysis is welcome, but it is introduced in such fashion that its principal treatment *follows* the sections that it could best illuminate and organize. Except for the first section, there is a somewhat regrettable lack of development around available theories in favor of a more encyclopedic approach.

These are things, however, that a skillful teacher can take into account, and they should not seriously reduce the book's potential usefulness. They should not be problems at all for the practicing psychologist who wants a sound, critical evaluation of recent developments. The field of tests and measurements seems about to embark on a new era in response to many recent and important developments. In some ways, Anastasi's book represents an excellent summary of progress. In other ways, it heralds the new directions of attack on critical problems of this field.

JOHN W. GUSTAD
Department of Psychology, University of Maryland

Renal Function. Trans. of the Fifth Conference 14–16 October 1953, Princeton, N.J. Stanley E. Bradley, Ed. Josiah Macy, Jr., Foundation, New York, 1954. 218 pp. Illus. $3.75.

Since 1942 Frank Fremont-Smith has organized and directed, under the aegis of the Macy Foundation, a series of interdisciplinary conferences on medical and allied topics in which integration of the activities and accomplishments of workers in different fields seems especially called for. Not only has the interchange around the conference table proved of great value to the participants, but the published transactions have been notable evaluations of the status of the topics discussed, in a fashion that could be achieved only when the presentation of the investigator is subjected to questioning by *cognoscenti* in the field.

This volume records the fifth and last conference on renal function. The subjects included are "The nephrotic syndrome," by John A. Luetscher, Jr.; "The problem of kidney transplantation," by Benjamin F. Miller; and "Acute renal failure," by Graham McGregor Bull. Each essayist presents original and important work, and the uninhibited give-and-take of the discussion brings out the shadows as well as the highlights.

Luetscher details the most recent results of his important studies on sodium-retaining substances in the urine of patients with the nephrotic syndrome as well as the role of these substances in the pathogenesis of the edema. He finds that the sodium-retaining activity of nephrotic urine resides in a single chromatographic fraction with the reactions of an adrenocortical steroid.

Miller presents remarkable results with homotransplantation of the kidney in man. In one patient the transplanted kidney functioned for more than 5 mo. In an individual with polycystic disease, the transplanted kidney formed 2850 ml of urine on the 18th day, and on the 21st day there was an inulin clearance of 14.4 ml/min as contrasted with 2.1 ml by the polycystic kidneys.

Bull's work concerns renal function and treatment in acute tubular necrosis. Contrary to much (not all) opinion in this country, Bull prefers conservative management to dialysis.

The content of this volume is more clinical than that of the four preceding ones. It can be heartily recommended to clinicians interested in kidney disease, and it will prove of value to workers in renal physiology.

ARTHUR M. FISHBERG
Department of Medicine, Beth Israel Hospital

Diagnostic Cytologique du Cancer Génital chez la Femme. Raymond Bourg, Claude Gompel, and Jean-Paul Pundel. Masson, Paris, 1954. xiv + 176 pp. + atlas. Illus. + 84 plates. F. 4800.

For the English-speaking reader, the main interest of this book lies in the fact that, according to the authors, this is the first book in French that deals with the cytological diagnosis of genital cancer of the woman. Written for the use of practicing physicians, the book gives a comprehensive and vivid description of the usefulness, limitations, methods, and techniques of exfoliative cytology in investigation of female genital pathology. The illustrations and microphotographs, which comprise the larger part of the book, are clear and instructive and should prove very helpful to anyone starting to investigate exfoliated cells. A short description of the cyclic changes that occur in the vaginal epithelium and of their importance in the study of normal hormonal functions might have made the treatment of the subject more complete. The book may be of great value in disseminating the knowledge of a method, the importance of which has been proved and is now routinely used throughout America.

CORNELIA HOCH-LIGETI
Department of Pathology, University of Virginia

Isotopic Gas Analysis for Biochemists. R. F. Glascock. Academic Press, New York, 1954. viii + 247 pp. Illus. $5.80.

Methods for the radioactive analysis of carbon-14 and tritium as gaseous compounds are generally more sensitive and more precise than solid-sample radioactive assay procedures. Although gas-phase procedures have been used for many years, such methods are not as widely used as they could be. Part of this lack of use stems from the expense for complex gas-handling and electronic equipment, but part of the trouble comes from lack of usable information for

the biochemist. The author of this book has tried to correct this situation by reviewing known methods of radioactive gas analysis that are of interest to biochemists. The major subjects covered include vacuum techniques, gas-phase assay of carbon-14, combustion of labeled compounds, and assay procedures for deuterium and tritium. A short section on the synthesis of tritium-labeled compounds is interesting, but it is not indicated by the title.

In several respects the title of this book is misleading. Generalized isotopic gas-analysis methods are not discussed in detail but rather the preparation of samples for isotopic gas analysis. The gas-analysis methods that are described are mostly for radioactive isotopes. No discussion is presented on mass spectrometer or infrared isotopic gas analysis. The book is primarily a laboratory manual devoted to the gas-handling techniques in use in the author's laboratory, and no effort has been made to give a systematic review of the literature on vacuum and gas-handling techniques or on isotopic analysis methods.

The radioactive gas-assay procedures for carbon-14 that are discussed in some detail include Geiger counting of CO_2 using CS_2, proportional counting of CO_2 and acetylene, and ionization chamber assay. The section on the Brown-Miller method for Geiger counting of CO_2–CS_2 mixtures is very interesting. This excellent procedure is not as widely used in the United States as it might be, and perhaps this book may help.

A considerable section of the book is used to describe procedures for the combustion of labeled compounds either by the Van Slyke oxidation mixture or by using various dry combustion methods. This is a very critical part of isotopic gas analysis, and such a review is needed.

This book is carefully written and well constructed and contains very few errors. It is a useful laboratory reference for the biochemist working with isotopes, particularly if he uses gas-assay procedures for carbon-14 or tritium.

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Transactions of the Symposium on Fluid Mechanics and Computing. Sponsored by the American Mathematical Society and Office of Ordnance Research, U.S. Army. Garrett Birkhoff, K. O. Friedrichs, and T. E. Sterne, Eds. Interscience, New York–London, 1954. 243 pp. Illus. $5.

This book, a reprint of 14 papers published in *Communications on Pure and Applied Mathematics*, volume VII (1954), constitutes the proceedings of the first Symposium on Applied Mathematics. The papers are concerned with modern problems of fluid mechanics (shock waves, turbulence, boundary layers, transonic flow, compressible fluid flow), and the associated mathematical problems. These last include not only analytic treatments of the complicated partial differential equations encountered in treatments of the foregoing subjects and related matters but also discussions of numerical methods of solution, including the use of large-scale computers. One paper is experimental (measurement of spherical shock waves). The contributors include many outstanding names in the fields mentioned. The treatments are authoritative and advanced, and they will interest specialists in fluid mechanics and applied mathematics.

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New Books

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Technical Papers

The Thalamus and Temporal Orientation

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Disturbances of temporal orientation have been observed chiefly in conditions causing diffuse impairment of cerebral function, sometimes in diseases affecting the parieto-occipital region or large areas of the brainstem. We had occasion to observe such disturbances in the initial stages after dorsomedial thalamotomy (*1*). Although these symptoms were only transitory, they seem of sufficient general interest to warrant a more detailed description and analysis (*2*). Since we find in our material a rather elementary disturbance of orientation in time, we have avoided the term *agnosia,* which we reserve for more complex types of dysfunction, and have chosen instead the term *chronotaraxis* (confusion in time) to indicate that confusion in temporal orientation is the most prominent symptom.

Since a study of this symptom in patients who preoperatively show severe defects of intelligence or disturbances of orientation is, of course, hardly possible, our material is restricted to 30 cases, patients who underwent thalamotomy for the relief of chiefly emotional disturbances or intractable pain. Before operation these patients were well oriented in time and place and they were in good contact with their environment. Of the 30 cases studied, 19 showed more or less pronounced chronotaraxis, four showed disturbance of orientation in time and place, and seven showed no such disorders. In most instances the chronotaraxis lasted a few days or weeks; in only one case did it last 6 mo.

The patients were confused regarding the date, the season, and the time of the day; they misstated their age and/or that of their children. They made serious errors regarding the duration of the time elapsed since operation, their stay in the hospital, or their home. Each individual's mistakes were usually in a definite direction: some showed a tendency to overestimate, others to underestimate the duration of their experiences. Furthermore, as observed by Heimann in scopolamine poisoning (*3*), a dissociation between the estimation of time by "feeling" and its judgment by empirical, intellectual factors was observed after the thalamic lesions; for example, 2 mo after thalamotomy, one patient knew from repeated discussions with her family and with the interviewers that she had lived in her home for 5 yr; but she expressed the feeling that she had resided in her home for only a few weeks.

Another patient reported postoperatively a peculiar feeling that the day finished within a few hours, although she knew that only a short time had elapsed since morning; this feeling was repeated several times during the same day. These observations seem to support the view that isolated disturbances of the immediate perception of time duration do exist; they also show that such disturbances may be caused by circumscribed thalamic lesions. Although a constant relationship to anosognosia or to emotional changes could not be established, there were usually memory defects affecting recent, as well as remote, events. These memory defects may be an important component of the temporal disorientation; however, they seem insufficient to explain the aforementioned syndrome.

The operative coordinates and postoperative x-ray studies of pantopaque droplets injected at the site of the lesion indicate that the dorsomedial nuclei were chiefly involved. Since temporal disorientation was observed in single cases after prefrontal lobotomy (*4*), it seems possible that interruption of the circuit that connects the dorsomedial nuclei with the frontal lobe plays an important role in the genesis of the temporal disturbance after lesions of these nuclei.

However, since these disturbances do not appear in all cases and, if present, are only transitory, the possible participation of other circuits in the underlying mechanisms must be considered. The lesion may encroach upon parts of the diffuse thalamocortical projection system such as the intralaminar nuclei. It seems, however, somewhat doubtful that the depression of cortical activity caused by lesion of these latter nuclei plays an important part in the production of our syndrome, for this system seems dispensable for cortical activation on stimulation of the reticular formation of the brainstem (*5*). If asymmetric lesions are produced inadvertently, so that on one side medial parts of the lateral nuclei are affected, the nuclei lateralis dorsalis and lateralis posterior may be injured where parietopetal fibers originate. Associated lesions of this latter system may be significant in view of the fact that temporal disturbances were observed in lesions of the parietal lobe (*6*).

An extension of the lesion in frontal direction to the anterior nuclei-mamillary body system is still more important. This is illustrated by a case in which transient temporal disorientation following lesion of the dorsomedial nuclei reappeared several months later when a more cranial lesion including the anterior nuclei was added. Furthermore, in single instances, localized processes in the area of the mamillary body were associated with a Korsakoff syndrome (*7*) that is, at least in some respects, similar to our syndrome. However, it should be emphasized that severe lesions of the mamillary bodies do not necessarily induce a Korsakoff syndrome (*8*). In view of these various observations, it does not seem possible to relate the mechanisms involved in temporal orientation to single

nuclei or their cortical connections. The observations seem to be explained best by the assumption that multiple circuits participate in the mechanism of temporal orientation, so that a lesion of a single thalamic nucleus produces only transitory disturbances.

Following lesions of other subcortical regions (midbrain in the area of the spinothalamic system; pallidum) chronotaraxis was not observed.

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Lack of Lens Induction by Eye Cup

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In amphibian embryos, trunk ectoderm can be induced to form a lens at the neurula stage; in later stages, depending on the species involved, lens potency is restricted to the ectoderm surrounding the eye and, then, is lost altogether (*1*). However, the eye cup still retains its lens-inducing ability for some time, and in *Triturus*, even in adults, the eye cup can induce a neoformation of a lens from the upper rim of the iris. In a series of publications, several Soviet authors (*2–4*) reported that the trunk ectoderm of early and late embryonic stages, and even tadpole ectoderm, could be transformed into lens tissue when transplanted into the eye cavity of the tadpole. According to later reports, the chordomesoderm and the tail skin of the metamorphosing tadpole reacted in the same manner (*5*).

Somewhat different were the experiments of Törö (*6*). He cultured embryonic chick and rat iris epithelia *in vitro*; after some 10 explant generations he implanted them back into the eyes of the young animals, after the lens had been removed. Well-formed lenses could be observed in these eyes a few days after operation. Törö supposed that the iris epithelium dedifferentiated in tissue culture and acquired the ability to be converted into a lens when exposed to the induction of the eye. The reported experiments demonstrated both lens potency in tissues that were believed unable to form a lens and strong lens-inducing properties in fully developed eyes. These interesting observations deserved independent confirmation, and we tried to repeat the experiments, using locally available amphibians and chicks (*7*).

The types of experiments performed are summarized in Table 1. In *Rana pipiens*, tadpoles with posterior leg buds, or slightly younger, served as hosts. The lens of one eye was removed through an opening in the cornea. Pieces of trunk ectoderm from the neurula or early or late tail-bud stage, were then introduced with a micropipette into the lenseless eye. In the majority of experiments, the implant could not be found in fixed preparations of tadpoles killed 1 wk or later after operation. When the implant was not expelled or resorbed, it showed an epithelial vesicle with no indication of lens formation. The cells partially lost their pigment, and the center of the vesicle contained expelled yolk and pigment granules.

Removing the lens in *Ambystoma gracile* and *A. maculatum* larvae was easy, and implanting other tissues was successful in most cases. The operative technique was similar to that previously described for *Triturus* (*8*). The hosts were larvae with three- or four-toed hind legs. Trunk ectoderm from the neurula or early or late tail-bud stage, was implanted into the eye. The implanted piece rounded into a vesicle that usually settled near the pupil. Four days after the operation, a general depigmentation of the vesicle was observed. Some cells lining the center of the vesicle still contained pigment granules, but the cells facing the eye cavity were free of pigment. The yolk granules and most of the pigment were expelled, either into the central cavity of the vesicle, or into several smaller cavities inside the vesicle wall (Fig.

Table 1. Implantation of embryonic ectoderm and iris epithelium into lensless eyes. Harrison stages for *Ambystoma*, Shumway stages for *Rana pipiens*. Iris tissue culture from 12-day-old embryos was implanted in *Gallus gallus*.

Host	Stage of donor	Duration of experiment (days)	Eyes operated	Successful implantations
Rana pipiens	20	5	6	5
		7	8	3
		14	13	2
		21	12	7
Ambystoma gracile	22	4	7	4
		7	10	4
		10	8	7
		14	12	12
A. maculatum	20	7	11	8
		14	10	8
		21	10	9
	30	7	14	14
		14	12	12
		28	20	18
	38	14	14	12
		28	14	13
Gallus gallus		9	1	1
		14	6	3
		28	4	2

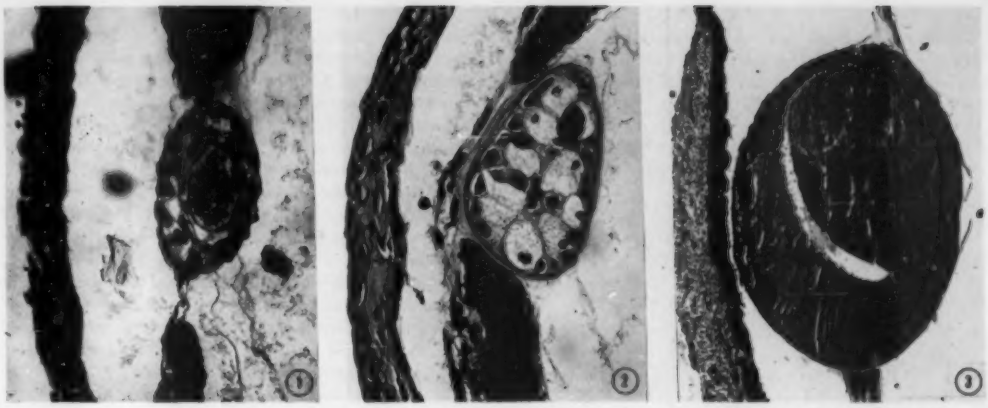

Fig. 1. Ventral ectoderm of *A. gracile* (embryo stage 22) implanted into larval eye, 14 days after operation. Fig. 2. Ventral ectoderm of *A. maculatum* (embryo stage 30) implanted into larval eye, 28 days after operation. Fig. 3. Lenslike formation observed in chick eye 28 days after incomplete lensectomy.

1). A conspicuous basal membrane surrounding the vesicle appeared in 14-day-old implants. The epithelium resembled corneal tissue more than it did a regenerating lens vesicle. After 21 days the implants remained unchanged, except that, in some cases, they contained Leydig's skin gland cells, such as are found in the ventral skin of an embryo of an age equivalent to the age of the explanted ectoderm (Fig. 2).

To repeat Törö's experiments, chick iris from 12-day-old embryos was explanted in hanging drop cultures and neutral red was added (*6*). After 8 to 10 transplantations, pure cultures of iris epithelium were secured. These iris cultures were implanted into the eyes of newly hatched chicks, after the lens had been removed. The chicks were killed and the operated eyes were fixed after indicated periods (Table 1). The implanted epithelium could be recognized easily in several preparations, adjacent to the remains of the capsula lentis, where it grew in a discoid formation several layers thick. It was heavily pigmented and showed no transformation into lens tissue. In the operated eyes, lenslike formations remarkably similar to the ones illustrated by Törö were found (Fig. 3); these could be formed only from the incompletely removed original lens. Similar lentoids were observed in control experiments when the lens was removed but no implant introduced. Eyes fixed immediately after operation contained the remains of the original lens, and these remains could be observed in operated eyes *in vivo*.

The attempt to repeat the experiments of the Soviet authors (*2–4*) and of Törö (6) gave only negative results. The trunk epithelium, implanted into larval eyes, did not form lens tissue, but it showed, temporarily, a similarity to corneal tissue. The expulsion of the yolk granules and the pigment could have been an effect of specific forces in the surrounding eye or, perhaps, an effect of a liquid medium as is observed (*9*) in the cultures of iris epithelia. The ultimate formation of Leydig's gland cells showed that no real change in the prospective potency of the implanted epithelium occurred. It is interesting to note that the polarity of the implanted epithelium was reversed: the embryonic ectoderm, when prepared for implantation, curled in small balls, leaving the original skin surface exposed; inside the eye, this same surface was covered with the basal membrane.

Our results are not in accord with those of the Soviet workers, but the possibility remains that variation of experimental material might account for the difference. Verejskaja (*10*) attempted analogous experiments with rats by implanting embryonic ectoderm into the eye cavities of young animals. All implants developed typical skin formations, but, in 98 percent of the experiments, the remains of incompletely removed lenses were observed.

Okada (*11*) and Reyer (*12*) presented an extensive criticism of the work of the Soviet authors that is supported by our negative results. It is very difficult to remove complete lenses from anurans, chicks, or rats. The remaining lens epithelium can produce lens formations (*13*) that can be easily misinterpreted as formations from the implants. As Okada pointed out, the lenses were observed 1 to 3 days after implantation by the Soviet authors, in a period of time in which no implanted tissue could be expected to give such large or complete lenses. It takes 4 days to produce a lens with fibrils from the lens placode in the frog embryo, and 7 days to regenerate the lens with fibrils in *Triturus* larvae. Any debris of leftover lenses could, on the other hand, originate these formations. There is also the possibility that the depigmented ectodermal vesicles were mistaken for young lens vesicles. Only the presence of lens fibrils would confirm the real lens nature of the tissue.

In chicks, cultured iris epithelium did not develop into a lens when it was implanted into lensectomized eyes, but lentoids were formed from incompletely re-

moved lenses. Such partial reconstitution of lenses, which is not a true regeneration, has often been reported (*13*). Törö's contrary results should be evaluated in the light of this knowledge.

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7 February 1955.

Ultraviolet Polymerization of Monomeric Methacrylates for Electron Microscopy

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Specimens to be sectioned for electron microscopic techniques are usually imbedded in monomeric methacrylate mixtures that are subsequently polymerized by the addition of a suitable chemical catalyst and the application of heat (*1*). However, because of the small quantities of monomer used, it is often inconvenient and/or difficult to dissolve the catalyst. In addition, chemically catalyzed samples have a tendency to develop undesirable bubbles during polymerization.

Massey (*2*) reported that tissue imbedded in chemically catalyzed monomeric methacrylates often suffers from a "popcorn reaction." To minimize the disadvantages of chemical polymerization, Massey suggested the use of ultraviolet polymerization of uncatalyzed monomers from which the inhibitor had been removed. Her ultraviolet source appears to have been a type RS-40 sun lamp designed for home use. However, this sun lamp also emits large amounts of infrared radiation, and its operating temperature is so high that it will char paper on contact. This necessitates special precautions against fire hazard during the long periods of continuous operation needed for photopolymerization. In addition, forced draft ventilation is usually necessary to avoid overheating of the specimen, and the effective irradiated area at the recommended distance is small and not uniform.

Because of the advantages of using photopolymerization, it was decided to develop a modified method. There are many commercially available radiation sources that can supply the near ultraviolet needed for the photopolymerization of monomeric methacrylates. Most of these, however, require special electric equipment or have such high emission values that the small samples used may boil. It was, therefore, decided to employ a lamp of relatively low emission value that would still result in photopolymerization within a convenient period of time.

The lamp chosen was a Westinghouse FS20T12 fluorescent sun lamp (*3*). This lamp is physically and electrically similar to a standard 20-w fluorescent lamp and operates in standard 20-w fluorescent-lamp fixtures. It has approximately the same emission range as the RS-40 sun lamp, an effective life of about 4000 hr, a normal operating temperature of about 100°F, and very little infrared radiation. No forced draft ventilation is necessary.

The sun lamp was utilized in conjunction with a standard 20-w fluorescent channel-strip fixture containing lamp holders, starter, and ballast (Fig. 1). A polished aluminum reflector, *R*, with a 1⅛-in. radius of curvature was attached to the unit. The reflector was designed so that it also served as a mount for the specimen holders, *H*, and backing reflectors, *BR*.

Specimens were imbedded in No. 4 gelatin capsules using a mixture of 1 part ethyl methacrylate and 3 parts *N*-butyl methacrylate (*4*) from which the inhibitor had been removed. The filled capsules, *S*, were then attached in a vertical position to a strip of cellulose tape, *T*, that had been fastened to a specimen holder, *H*. The specimen holder was then clipped

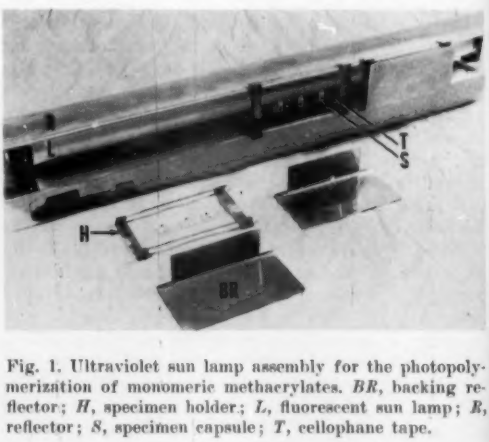

Fig. 1. Ultraviolet sun lamp assembly for the photopolymerization of monomeric methacrylates. *BR*, backing reflector; *H*, specimen holder; *L*, fluorescent sun lamp; *R*, reflector; *S*, specimen capsule; *T*, cellophane tape.

over the open end of the reflector, and a polished aluminum backing reflector, *BR*, was placed in position.

It is preferable to utilize capsules that contain prepolymerized plugs at the bottom (*2*). These are prepared in advance by photopolymerizing 2 drops of the methacrylate mixture in No. 4 gelatin capsules.

When the photopolymerization unit described in this paper (*5*) is used, the specimens are positioned approximately 1 in. from the surface of the fluorescent lamp. Up to three horizontal rows of specimen capsules can be accommodated over the full available length, approximately 22 in. Thus, more than 100 specimens can be photopolymerized at one time. Full capsules are polymerized by an overnight exposure to the ultraviolet radiation. However, preparation of the methacrylate plugs may require exposures of 24 to 48 hr because of air inhibition.

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4. Obtained through the courtesy of Rohm & Haas Co., Philadelphia, Pa.

5. This investigation was supported by a grant from the Life Insurance Medical Research Fund.

10 November 1955.

Brei Fractionation

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It does not appear to have been generally realized that the centrifugal procedures used for brei fractionation have a much lower resolution than would be expected from a simple uncritical application of Stokes' law. Techniques for fractionating breis have therefore been investigated in this laboratory during the past 3 years with the aim of developing an analytic medium-speed centrifuge (*1*). The equipment presently in use incorporates a shatterproof glass observation port on the centrifuge, a stroboscopic system providing both high- and low-intensity illumination, circuitry for constant and variable flashing rates, a contactor on the centrifuge shaft that allows a stable image to be observed during sharp changes in speed, a speed-measuring system for indicating speeds down to 25 rev/min (accuracy > 0.02 percent), and a system for recording data for speed-versus-time curves. With the latter, the total effective centrifugation may be integrated. Cut-out centrifuge tube shields allow the behavior of breis and layered systems to be observed directly during centrifugation.

Layered systems, which are necessary for high-resolution work, are subject to several artifacts. The first, shown in Fig. 1, occurs in a matter of minutes

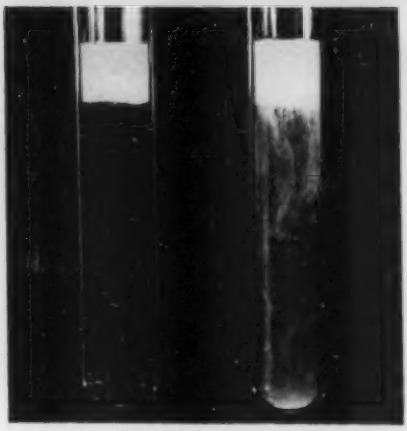

Fig. 1. Streaming effect in a layered system. A 10-percent rat liver brei in 0.25*M* sucrose-0.0018*M* $CaCl_2$ (density 1.038) layered over 0.34*M* sucrose-0.00018*M* $CaCl_2$ (density 1.046). (Left) System immediately after layering. (Right) Streaming after 30 min at 0°C (not centrifuged).

without any centrifugation in a layered system such as the one advocated by Hogeboom *et al.* (*2*) for nuclear isolation. Nuclei, whole cells, and mitochondria are all carried down indiscriminately. This *streaming effect* involves the movement of droplets and does not appear to depend on the sedimentation of individual particles. The second effect is introduced by the use of centrifugal fields sufficient to move particles across the density interface. The upper portion of the lower, denser layer increases in density by virtue of the particles entering it from above and moves to the bottom of the tube, resulting in a *turnover effect* (Fig. 2). This accounts for the poor resolution of most layered systems. The use of a number of discrete layers of different densities does not solve

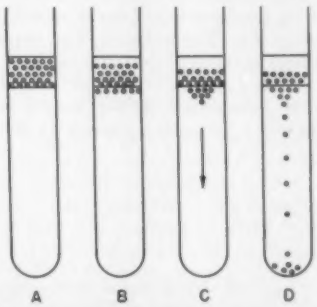

Fig. 2. Turnover effect. A suspension of particles layered over a denser medium (*A*) is centrifuged until some of the particles have passed the interface (*B*). The upper part of the lower layer is then denser by virtue of the particles it now contains. It moves as a body to the bottom of the tube (*C*, *D*).

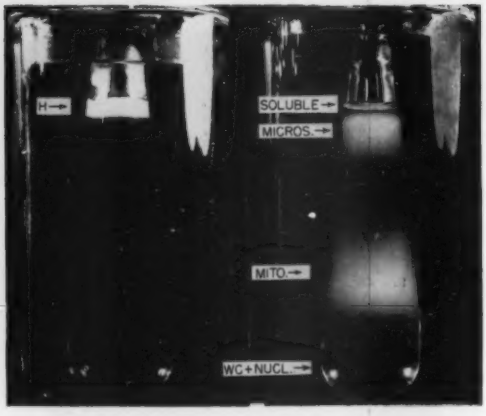

Fig. 3. Separation achieved in a continuous sucrose gradient. (Left) Before centrifuging; (right) after centrifuging. Two milliliters of 5-percent rat liver homogenate was used.

the problem, because the same effect occurs at each interface. This results in the accumulation of particles above each interface with little difference in the microscopic appearance of the various layers (*3*).

With cylindrical centrifuge tubes an appreciable portion (in some instances as much as 50 percent) of the sedimented material hits the side of the tube before it reaches the bottom. This difficulty is met by the use of modified sector-shaped tubes, which are used routinely in this laboratory.

Other difficulties arise during centrifugation because of changes in tube orientation and uneven acceleration and deceleration. These have been eliminated by the use of a reproducible system for slow, controlled acceleration and deceleration.

The difficulties described have been further minimized by use of a *continuous density gradient* produced by differentially driven pistons. Other methods for producing gradients have been examined and found unsatisfactory for this purpose. The characteristics of the gradient in terms of density, viscosity, and composition are accurately known. The results obtained with a dilute homogenate layered over a continuous gradient having a very steep increase in density near the bottom are shown in Fig. 3. No cross-contamination of nuclei, mitochondria, or microsomes has been observed microscopically. A considerable difference in the appearance of particles at the top and bottom of the mitochondrial layer is seen. With longer centrifugation the microsomes have been completely separated from the soluble layer.

All fractions may be quantitatively recovered by introducing a very dense solution to the bottom of the tube, floating the undisturbed gradient into either a constricted portion of the tube or into a sliding system for shearing the liquid similar to that used in the Tiselius cell.

It is evident from Fig. 3 that the continuous spectrum of particles ranging from mitochondria to microsomes, which had been postulated on the basis of previous centrifugal techniques (*4*), does not exist. It is now feasible to make quantitative studies of changes in the ratios and total amounts of brei fractions in response to experimental conditions. The techniques are of interest in connection with virus purification, platelet isolation, and the separation of small particles generally. Since the smaller particles need be moved only a relatively short distance, high gravitational fields are not required.

Continuous gradients were first employed by Behrens (*5*) for the isopycnic separation of nuclei and cytoplasm in nonaqueous media. Steep short gradients of sucrose were introduced by the Harveys (*6*) for the stratification and separation of marine eggs into nucleate and nonnucleate halves. I employed starch gradients in 1949 (unpublished) in attempts to separate cytoplasmic fractions. The techniques described here are an extension of that work. Sucrose gradients for the isolation of plant viruses were introduced by Brakke (*7*).

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16 February 1955.

It is certain that a serious attention to the sciences and liberal arts softens and humanizes the temper, and cherishes those fine emotions of which true virtue and honor consist. It rarely, very rarely happens that a man of taste and learning is not, at least, an honest man, whatever frailties may attend him.—DAVID HUME.

Communications

Radiochemical Separations by Isotopic Exchange: a Rapid, High-Decontamination Method for Silver

It has been reported by Langer (*1*) that the exchange of silver ion between a precipitate of silver chloride and a solution of silver nitrate reaches isotopic equilibrium very rapidly. Because of the low solubility of silver chloride, a very favorable ratio exists at equilibrium between the silver atoms in the precipitate and the silver atoms in the solution. For this reason, if silver chloride is added to a solution containing only trace amounts of radioactive silver, a high percentage of this silver will have exchanged with the silver in the precipitate by the time equilibrium is attained. Use has been made of this fact to develop a rapid, high-decontamination, single-step method for the separation of traces of radioactive silver from a solution containing other radioactive species (*2*).

Platinum gauze is coated with metallic silver by plating (*3*) from an alkaline cyanide bath. The silver is then changed to silver chloride by reversing the current and electrolyzing the silver in an HCl solution.

To separate radioactive silver from other activities (except halides), the "silver chloride electrode" is immersed for 5 min at room temperature in about 10 ml of an acid solution containing the active material. The solution may be stirred magnetically. The electrode is removed and washed with a stream of 1:1 HNO_3 for 1 min.

Yields of radioactive silver from this procedure are given in Table 1 for varying temperatures, amounts of silver chloride, and times of immersion. The exchange rate appears to be independent of the nitric acid concentration in the range of 0.1 to 4*M*, whereas at 8*M* HNO_3 only 92 percent and at 16*M* HNO_3 only 50 percent is exchanged in 5 min at 25°C. The exchange is also independent of hydrochloric acid concentration in the range 0 to 0.6*M*, whereas in 1.2*M* HCl only 77 percent and in 6.0*M* HCl only 30 percent of the silver is exchanged in 5 min at 25°C. This effect of HCl is noted only as long as the silver concentration is so low that the solubility product of silver chloride is not exceeded in the tracer solution before immersion of the electrode. Higher concentrations of silver in hydrochloric acid were not investigated.

Table 1. Yields of radioactive silver from 1*M* HNO_3 by exchange procedure.

AgCl (mg)	Immersion time	Temp. (°C)	Recovery (%)
2	5 min	25	> 97
2	2 min	95	> 98
2	20 sec	95	50
0.3	5 min	25	85–90

A study of the decontamination afforded by this procedure showed a decontamination factor of 2×10^4 with 4-yr-old fission products and a factor of at least 10^4 with cadmium freshly bombarded with 7.8-Mev deuterons in the University of Michigan cyclotron. In addition, when carrier-free iodine was oxidized with permanganate and nitric acid, a decontamination of 10^4 was obtained. The advantages of this exchange method include its rapidity, its high decontamination in a single step, and simplicity of manipulation. Greater than 98-percent recovery is possible as long as the weight of solid inactive silver chloride is at least 50 times the weight of tracer silver in the solution.

This method should find use in radiochemical assay work when simplicity and speed are essential. It should be useful in characterization studies of short-lived silver activities in bombardment work and in the rapid determination of silver in fission products. It should also prove useful in the rapid preparation of high specific activity silver from irradiated materials such as palladium. It is readily adaptable to work with high levels of radiation when handling by remote control is required.

Experiments with this method of separation are continuing, and its applicability in other cases such as the exchange of iodide with silver iodide is being studied.

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17 March 1955.

Prepottery, Lithic Complex from Sonora, Mexico

In the vicinity of Hermosillo, the capital of Sonora, Mexico, during the summer of 1953, I examined a group of seven campsites that represent a prepottery, lithic complex, very similar in type to the Cochise culture of southeastern Arizona. If, after more thorough study, a relationship is actually established between this complex and the prepottery cultures of the Southwest, then the southern range of Cochise influence will be greatly increased.

Topographically, the locale of these sites is predominantly a stretch of flat desert with little vegetation and no immediate evidence of a natural water supply. However, the Rio de Sonora flows approximately 1 to 2 mi to the south of the site area.

A majority of the stone artifacts recovered were fashioned by a percussion-flaking technique, and they show very limited evidence of retouching. These objects included (i) side and end scrapers, with the plano-convex form most common; (ii) crudely flaked knife blades; (iii) cobble choppers, the shape of which are similar to those of the southeastern California region; (iv) an abundance of large primary flakes, perhaps used as wedges for the opening of mussel shells; and (v) occasional projectile points. Three of the four projectile-point forms are comparable to those of the San Pedro stage of the Cochise, and the fourth bears a resemblance to the Pinto-Gypsum point of California. Slate and shale are the most commonly represented materials used in the manufacture of these stone implements, with basalt, jasper, quartz, and rhyolite porphyry also occurring. In addition, several one-handed bifaced manos, made from locally gathered granite rocks, were found. The surface survey disclosed no basin metates of the Cochise type.

The material recorded from this group of sites seems to correspond very favorably with the San Pedro stage of the Cochise culture (which in Arizona has been dated approximately 3000 to 500 B.C.), a period characterized by percussion-flaked chipped implements, but with the addition of a few pressure-flaked artifacts—particularly projectile points.

This Sonoran manifestation very probably represents a local variation of an ancient cultural horizon of the Southwestern desert area. The material briefly described here has been designated tentatively as the "Peralta culture," possibly a Sonoran variant of the Arizona Cochise.

The artifacts will be deposited with the Biblioteca y Museo de Sonora in Hermosillo when the study is completed. This field survey was originally contracted with the Instituto Nacional de Antropologia e Historia of Mexico City, and was financed in part by the American Philosophical Society of Philadelphia (Penrose Fund) and the Kansas Academy of Science. Bill Young, of Springfield, Massachusetts, served in the capacity of field assistant.

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13 January 1955.

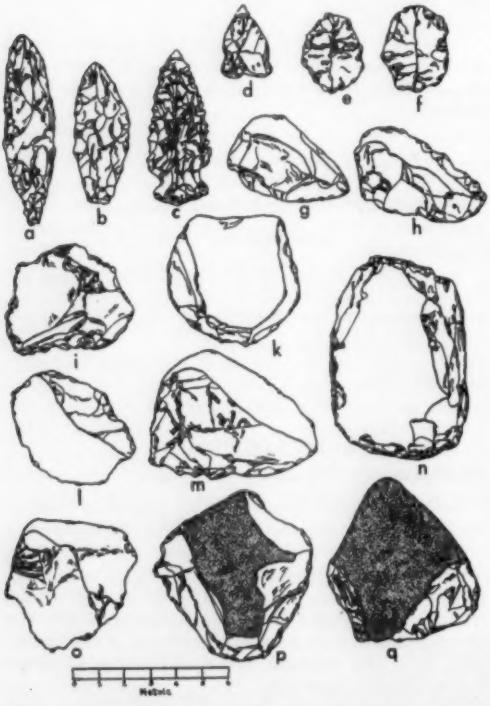

Fig. 1. Artifacts from the "Peralta" Cochise, Sonora: *a*, *b*, knife blades; *c*, *d*, projectile points; *e*, *f*, flake end scrapers; *g*, *h*, crude knife blades; *i*, *k*, plano-convex side scrapers; *m*, blunted side scraper; *l*, *o*, single flakes; *n*, side scraper-cutting edge; *p*, *q*, cobble end choppers.

Selective Service Policy and Scientific Manpower

I am writing this note to my colleagues in scientific work in the United States because I have learned from conversations with members of the United States Congress that in general the members of the Congress have not been made aware of the critical nature of the current problem concerning recruitment, education, and utilization of specialized manpower in this country. It has become apparent that if the selective service legislation for the next 2 years is to recognize in a realistic way the long-term interests of the community in developing and utilizing specialized manpower, particularly in the sciences, the members of the Congress must receive more information from their constituents.

The American scientific community has an obligation to the public to call forcefully to the attention of the Congress the real hazard involved in our current policies. Existing general selective service and doctors' draft policies and practices are a serious threat to the future security and welfare of the country. Under present circumstances too few young men of ability are entering training programs in the fundamental sciences.

The present laws expire soon, and the Congress is now considering the terms of new acts to be in force for the next 2 years. This is therefore the time for scientists who have the interests of the country at heart to give their advice to their senators and representatives. Loyalty involves action as well as acquiescence. Democracy cannot work unless citizens participate in the processes of government; one of the essentials of participation is the sharing of information concerning problems of public policy with public officials. Some scientists, and other citizens, pretend to a virtuous obliviousness to public questions. They seem to enjoy a make-believe escape into an imaginary ivory tower of detachment that does not and cannot

really exist today. The scientist is, in spite of himself, involved in public questions simply because science today so largely determines the issues of peace or war, prosperity or poverty, and health or disease.

The traditional reluctance of scientists to become involved in any issues irrelevant to their own work does not apply in the case at issue. The present issues are not irrelevant to the contribution of their work to the public good. Therefore, it is to be hoped that large numbers of scientists will make their views known to their own congressmen and senators and to the Armed Services Committee of the Senate and the Military Affairs Committee of the House of Representatives.

A constructive proposal that could be made to these committees is that a special national scientific manpower service board might be set up within the Selective Service System which would implement policy under the general directives of the Act of the Congress and would serve as a uniform national appeal board. The Act of the Congress should direct Selective Service to provide mechanisms for serving the long-term interests of the country with respect to scientific manpower, in view of the self-evident fact that we are in a situation of long-term, as well as short-term, crisis.

The Congress must be informed by knowledgeable persons if it is to act wisely. Scientists are obviously in the informed segment of the population with regards to scientific manpower problems. It is time for them to speak as individuals, as well as through organizations, because individuals vote and because widespread individual attention to a problem indicates real interest and concern.

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28 March 1955

New Apparatus for Prolonged Constant Infusion in the Unrestrained Animal

During the course of studies on the role of various hormones in the regulation of carbohydrate metabolism, it became necessary to perfuse the unanesthetized, unrestrained dog continuously and intravenously for periods of 1 to 3 mo. Current methods (*1*) involve the use of expensive perfusion pumps, which function satisfactorily for short periods of time but may not be adequate for prolonged continuous use.

The purpose of this communication is to describe an inexpensive, simplified infusion apparatus, recently devised in this laboratory, that does not require a pump and contains a minimum number of moving parts.

The apparatus consists of an infusion reservoir, an electronic resistance relay, a stainless steel solenoid valve, a control reservoir, and a micrometer valve (Fig. 1). The infusion reservoir consists of a series of standard infusion bottles (Abbott). These bottles supply the control reservoir through a stainless steel solenoid valve (General Controls K-21 F) with plastic fittings for tube adaptation. The level of the fluid in the control reservoir is maintained constant (2-mm variation) by two control electrodes (glass with platinum tip) that actuate the electronic resistance relay controlling the solenoid valve. The relay is commercially available (General Electric, Photoswitch, and others) or can be constructed from a variety of standard circuit diagrams (*2*). Beyond the control reservoir is a micrometer valve (Norgren) that regulates the infusion rate. Tygon tubing is used throughout, and the portion that is accessible to the animal is protected by BX armor. A glass blower's swivel is used to permit unlimited movement of the animal in the cage without twisting the tubing. The swivel is supported by a counterbalance weight so that no excess tubing is in the cage, regardless of the position of the animal. The entire apparatus costs about $70.

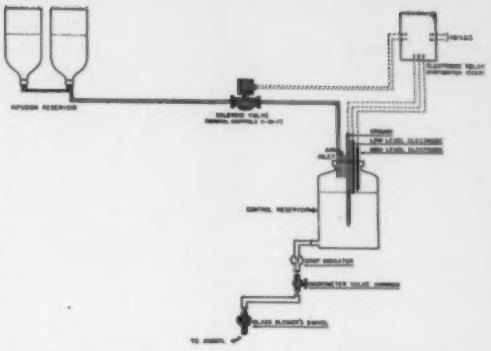

Fig. 1. Diagram of constant infusion apparatus.

This apparatus was successfully employed to perfuse the portal vein of an unanesthetized, unrestrained dog for 45 days. It is felt that the method has a variety of experimental applications.

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14 March 1955.

Calendar for Estimating Intervals in Days

Harris (*1*) has described a two-dimensional slide rule for the rapid calculation of time and other intervals. Table 1 shows, in a single chart, "days elapsed" and "days remaining" of the counting-house calendars commonly shown in diaries and desk calendars, together with multiples of 365. These data provide for the ready calculation of time intervals in days within

Table 1. Section of a counting house calendar for estimating intervals in days (*3*).

Jan.	Feb.	Mar.	Apr.	May	June
1 364	32 333	60 305	91 274	121 244	152 213
2 363	33 332	61 304	92 273	122 243	153 212
3 362	34 331	62 303	93 272	123 242	154 211
4 361	35 330	63 302	94 271	124 241	155 210
5 360	36 329	64 301	95 270	125 240	156 209
6 359	37 328	65 300	96 269	126 239	157 208
7 358	38 327	66 299	97 268	127 238	158 207

July	Aug.	Sept.	Oct.	Nov.	Dec.
182 183	213 152	244 121	274 91	305 60	335 30
183 182	214 151	245 120	275 90	306 59	336 29
184 181	215 150	246 119	276 89	307 58	337 29
185 180	216 149	247 118	277 88	308 57	338 27
186 179	217 148	248 117	278 87	309 56	339 26
187 178	218 147	249 116	279 86	310 55	340 25
188 177	219 146	250 115	280 85	311 54	341 24

a year or extending over several years (*2*). Thus, for calculating, on 30 Jan. 1955, the age of an animal born 28 Dec. 1951, the following data are summed:

Days remaining 1951	3
Days for 3 intervening years	1095
29 Feb. 1952	1
Days elapsed 1954	30
Age in days	1129

GERALD J. COX
Research Department, School of Dentistry, University of Pittsburgh, Pennsylvania

References and Notes

1. M. R. Harris, *Science* **118**, 309 (1953).
2. Developed in connection with a study supported by the American Cancer Society.
3. Copies of the calendar, within reasonable limits, can be obtained from G. J. Cox.

10 March 1955.

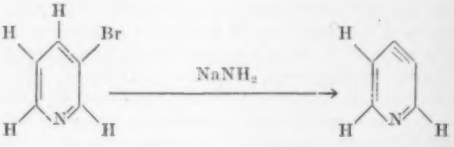
Rearrangement in the Reaction of 3-Bromopyridine with Sodium Amide and Sodioacetophenone

In connection with an extensive study of the chemistry of the tar bases and their derivatives, we have investigated the reaction of sodioacetophenone with 3-bromopyridine as a possible route to the unknown 3-phenacylpyridine.

From the attempted reaction of equivalents of 3-bromopyridine and sodioacetophenone—prepared from the ketone and sodium amide—in refluxing toluene, only the starting materials were isolated.

However, on processing a reaction mixture that was obtained by adding a liquid ammonia suspension of two equivalents of sodium amide to a liquid ammonia suspension of a mixture of one equivalent each of 3-bromopyridine and sodioacetophenone, there was isolated, in addition to a large amount of amorphous nitrogenous material, 13.5 percent of 4-phenacylpyridine (II), mp 112.6 to 113.6° (*1*) (from 60° to 70° petroleum ether) alone and when mixed with an authentic sample, and 10.0 percent of 4-aminopyridine (III), mp 157 to 158.4° (*2*) from benzene) [N-benzoyl derivative, mp 207° (from hot water). Analysis calculated for $C_{12}H_{10}N_2O$, N, 14.14; found, 14.20].

The formation of these compounds (II and III) may be rationalized by assuming an elimination-addition mechanism involving the transient existence of a "pyridyne" intermediate analogous to the "benzyne" postulated earlier by Roberts *et al.* (*3*) in the rearrangement of chlorobenzene-1-C^{14} when treated with potassium amide.



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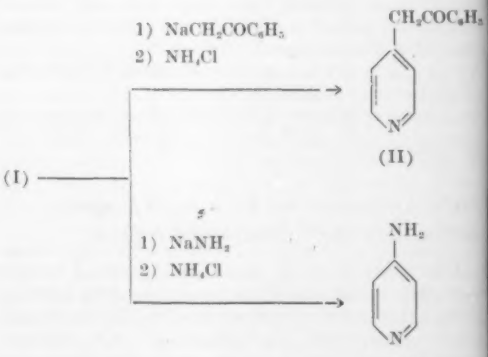

(III)

Further work is now in progress in this laboratory to determine the scope and limitations of this and related reactions.

ROBERT LEVINE
WILLIAM W. LEAKE*
Department of Chemistry, University of Pittsburgh Pittsburgh, Pennsylvania

References and Notes

1. J. M. Smith, Jr., *et al.*, *J. Am. Chem. Soc.* **70**, 3997 (1948).
2. E. Koenigs, G. Kenne, W. Weiss, *Ber. deut. chem. Ges.* **57**, 1172 (1924).
3. J. D. Roberts *et al.*, *J. Am. Chem. Soc.* **75**, 3290 (1953).
* Monsanto Chemical Co. research fellow.

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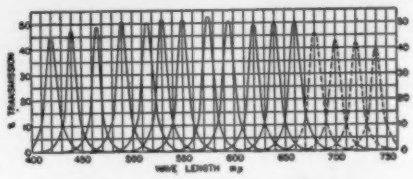

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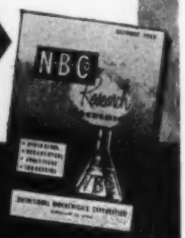

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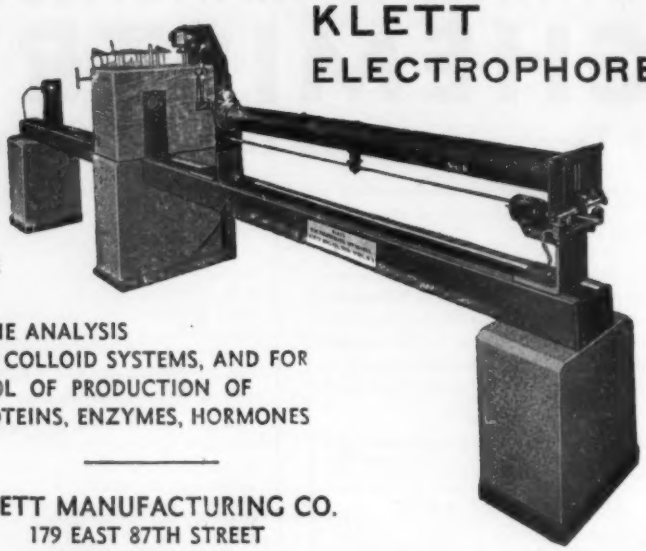

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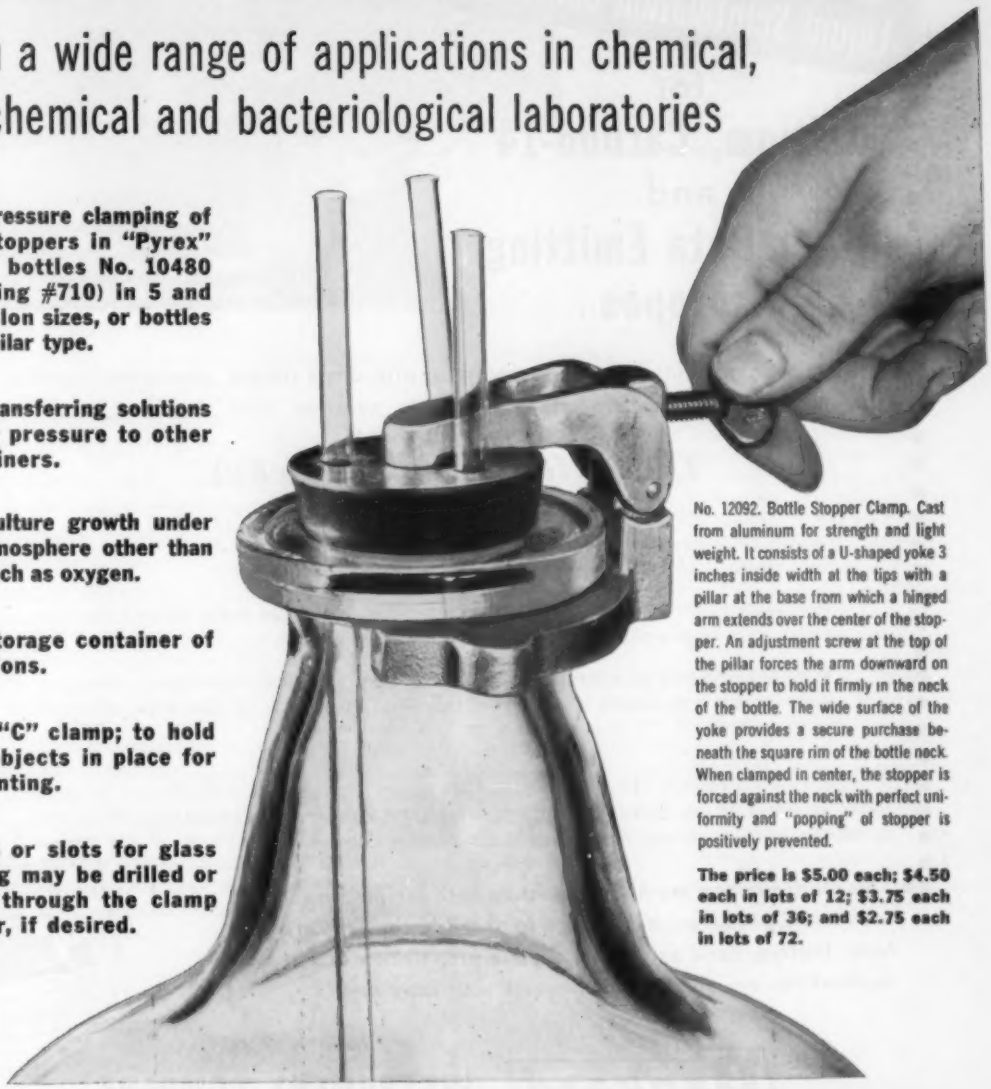

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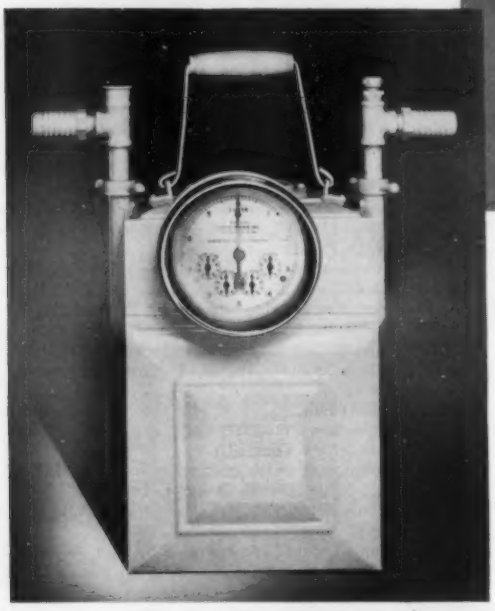

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Meetings & Conferences

June

14–16. Max Planck Soc. for the Advancement of Science, annual, Trier, Germany. (Max Planck Gesellschaft zur Forderung der Wissenschaften, Raiserswertherstr. 164, (22a) Dusseldorf, Germany.)

15–16. Operations Res. Soc. of America, 7th national, Los Angeles, Calif. (R. A. Bailey, Military Operations Res. Div., Lockheed Aircraft Corp., Burbank.)

15–18. Soc. for the Study of Development and Growth, 14th annual, Amherst, Mass. (M. V. Edds, Jr., Brown Univ., Providence 12, R.I.)

16–19. Automatic Factory—Institution of Production Engineers, Margate, Eng. (S. Caselton, 10, Chesterfield St., London, W.1.)

20–25. AAAS, Pacific Div., Pasadena, Calif. (A. W. Galston, Biology Div., California Inst. of Technology, Pasadena 4.)

21–23. American Dairy Science Assoc., East Lansing, Mich. (E. Weaver, Dairy Dept., Michigan State College, East Lansing.)

21–23. American Meteorological Soc., Pasadena, Calif. (K. C. Spengler, AMS, 3 Joy St., Boston 8, Mass.)

22–24. American Physical Soc., Toronto, Canada. (K. K. Darrow, APS, Columbia Univ., New York 27, N.Y.)

26–1. National Education Assoc., Chicago, Ill. (W. G. Carr, 1201 16 St., NW, Washington 6, D.C.)

27–29. American Nuclear Society, 1st annual, University Park, Pa. (W. W. Miller, Pennsylvania State Univ., University Park.)

27–29. American Soc. for Engineering Education, Thermodynamics Conf., University Park, Pa. (W. E. Ranz, Dept. of Engineering Research, Pennsylvania State Univ., University Park.)

23–25. Heat Transfer and Fluid Mechanics Institute, Los Angeles, Calif. (M. Tribus, Univ. of California, Los Angeles.)

27–29. American Soc. of Heating and Air-Conditioning Engineers, San Francisco, Calif. (A. V. Hutchinson, 62 Worth St., New York 13.)

27–29. Symposium on Reproduction and Infertility, East Lansing, Mich. (E. P. Reineke, Dept. of Physiology and Pharmacology, Michigan State College, East Lansing.)

27–30. Annual Conf. on Aging, 8th, Ann Arbor, Mich. (Div. of Gerontology, Univ. of Michigan, 1510 Rackham Bldg., Ann Arbor.)

27–1. American Crystallographic Assoc., California Inst. of Technology, Pasadena.

27–1. American Inst. of Electrical Engineers, summer general, Swampscott, Mass. (N. S. Hibshem, AIEE, 33 W. 39 St., New York 18, N.Y.)

27–1. Assoc. of Official Seed Analysts, Stillwater, Okla. (R. G. Colborn, Dept. of Agriculture, Lincoln, Neb.)

28–1. American Home Economics Assoc., annual, Minneapolis, Minn. (G. H. Johnson, 114 E. Park Pl., Newark, Del.)

28–9. British Instrument Industries' Exhibition, 3rd annual, London. (F. W. Bridges & Sons Ltd., Grand Bldgs., Trafalgar Sq., London W.C. 2.)

28–9. International Electrotechnical Commission, London, England. (American Standards Assoc., 70 E. 45 St., New York 17, N.Y.)

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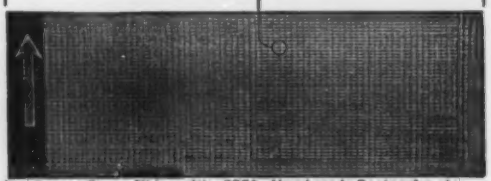

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